

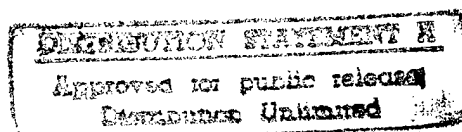
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U.S. Army
Environmental
Center

Demonstration Off-Post Groundwater Treatment Plant (Rowe Spring): Concept Design Report

Contract No. DACA31-91-R-0009
Task Order No. 03



July 1996

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Prepared for:
U.S. Army Environmental Center (USAEC)
SFIM-AEC-RPO
Aberdeen Proving Ground, MD 21010-5401

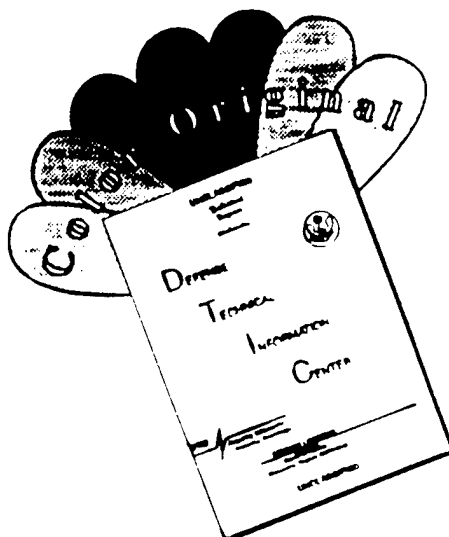
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TASK ORDER 3

**DEMONSTRATION OFF-POST
GROUNDWATER TREATMENT PLANT
(ROWE SPRING)
CONCEPT DESIGN REPORT**

July 1996

**U.S. ARMY ENVIRONMENTAL CENTER
SFIM-AEC-RPD
Aberdeen Proving Ground, Maryland 21010-5401**

Prepared by

**ROY F. WESTON, INC.
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12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified. Approved for public release. Distribution is unlimited.		12b. DISTRIBUTION CODE	
13. ABSTRACT The primary objective of this task was to develop an alternative treatment technique or an innovative use of a conventional technology to remove VOC contamination from Rowe Spring. A conceptual design for a treatment plant was to be prepared using the selected technology. Ten remedial technologies were evaluated using several criteria, including: ability to meet effluent requirements (non-detect for 9 VOCs), resident criteria (impact to surrounding human and animal populations, cost effectiveness, and other criteria). The selected groundwater remediation systems consist of a low-profile air stripping system and associated groundwater collection, conveyance, and post-treatment distribution systems. This report presents the concept design, conceptual level cost estimate, and geotechnical investigation report for the selected technology and treatment site.			
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EXECUTIVE SUMMARY

Letterkenny Army Depot (LEAD) is a U.S. Army owned and operated installation located in the central portion of Franklin County, Pennsylvania, 5 miles north of the City of Chambersburg. Consistent with its mission, LEAD generates industrial wastewater from a variety of sources, including metal plating, metal cleaning, parts and vehicle washing, and battery acid disposal. An Industrial Wastewater Treatment Plant (IWTP) was constructed in 1954 to treat this wastewater. The IWTP used a 1-million-gallon unlined earthen lagoon, underlain by karst limestone, to serve as a precipitation/flow equalization basin. A loss of liquids from the lagoon was first detected in the mid-1960s. Soon after that, the entire contents of the impoundment were lost when a sinkhole developed in the bottom of the lagoon and the wastewaters drained into the soils and groundwater below. Despite the efforts to repair the lagoon, various chlorinated solvents and volatile organic compounds (VOCs) were detected in 1985 in the underlying groundwater and eventually in Rowe Spring. As a result of this contamination source (and others), the southeastern portion of LEAD was listed on the National Priorities List (NPL) in July 1987.

The primary objective of this task was to develop an alternative treatment technique or an innovative use of a conventional technology to remove VOC contamination from Rowe Spring. Ten remedial technologies were evaluated using several criteria, including:

- Ability to meet effluent requirements (non-detect for VOCs)
- Residential criteria
 - Noise level contributed by the treatment system
 - Ability to provide supply of treated water for livestock
 - Compatibility with surroundings
- Other criteria
 - Cost effectiveness
 - Implementability
 - Maintenance required
 - Suitability for automation
 - Residuals generated

- Current availability
- Service life

The selected groundwater remediation system consists of a low-profile air stripping system (aspiration stripping—Hazleton Maxi-Strip process) and associated groundwater collection, conveyance, and post treatment distribution systems. A conceptual design for a treatment plant using the selected technology was prepared. Artistic renderings were prepared for the groundwater collection and discharge system building as well as the groundwater treatment building.

This report presents Rowe Spring characterization data, the concept design, artistic renderings, conceptual level cost estimate, and geotechnical investigation report for the selected technology and treatment site. The concept design includes a process flow diagram and a list of major components for the proposed groundwater collection and treatment system.



SECTION 1

BACKGROUND AND INTRODUCTION

1.1 INTRODUCTION

Letterkenny Army Depot (LEAD) is a U.S. Army owned and operated installation located in the central portion of Franklin County, Pennsylvania, 5 miles north of the City of Chambersburg. LEAD's current mission includes storage and maintenance of ammunition, vehicles, missile systems, and repair parts. Consistent with its mission, LEAD generates industrial wastewater from a variety of sources, including metal plating, metal cleaning, parts and vehicle washing, and battery acid disposal. An Industrial Wastewater Treatment Plant (IWTP) was constructed in 1954 to treat this wastewater. The IWTP used a 1-million-gallon unlined earthen lagoon, underlain by karst limestone, to serve as a precipitation/flow equalization basin.

A loss of liquids from the lagoon was first detected in the mid-1960s. Soon after that, the entire contents of the impoundment were lost when a sinkhole developed in the bottom of the lagoon and the wastewaters drained into the soils and groundwater below. In 1967, the lagoon was replaced by a two-celled, concrete-lined basin over the existing structure. Various chlorinated solvents and volatile organics were detected in 1985 in the underlying groundwater. As a result of this groundwater contamination, the southeastern portion of LEAD was listed on the National Priorities List (NPL) in July 1987.

A Resource Conservation and Recovery Act (RCRA) closure of the IWTP lagoons was completed in November of 1992. As part of this RCRA closure, LEAD was required to submit a Groundwater Abatement and Assessment Plan (GWAAP). Part of the GWAAP addresses groundwater contamination in Rowe Spring. The U.S. Army is currently addressing groundwater contamination at several off-post springs that contribute to the base flow of a nearby surface stream referred to as Rowe Run. Off-site sampling programs conducted in recent years have resulted in volatile organic compounds (VOCs) being detected in water samples collected at Rowe, Wirth, Helman, and Helman East Springs.



The objective of this document is to present a conceptual design for a treatment facility to remove chlorinated solvents from Rowe Spring.

1.2 LOCATION AND ENVIRONMENTAL SETTING

Rowe Spring is located approximately 1.25 miles east of LEAD and directly adjacent to Pennsylvania (PA) Route 433. The location of Rowe Spring is shown in Figure 1-1. The surrounding area is largely rural, with several farms operating in the area.

Rowe Spring emerges from the bed of Rowe Run onto a private property. Rowe Spring is the main source of constant water flow in Rowe Run. Rowe Run is a tributary to Muddy Run, which in turn discharges to Conodoguinet Creek. Water from Rowe Spring flows into a collection box from which a portion is used to water livestock. The remaining water in the collection box discharges through an outlet pipe in the side of the box to Rowe Run.

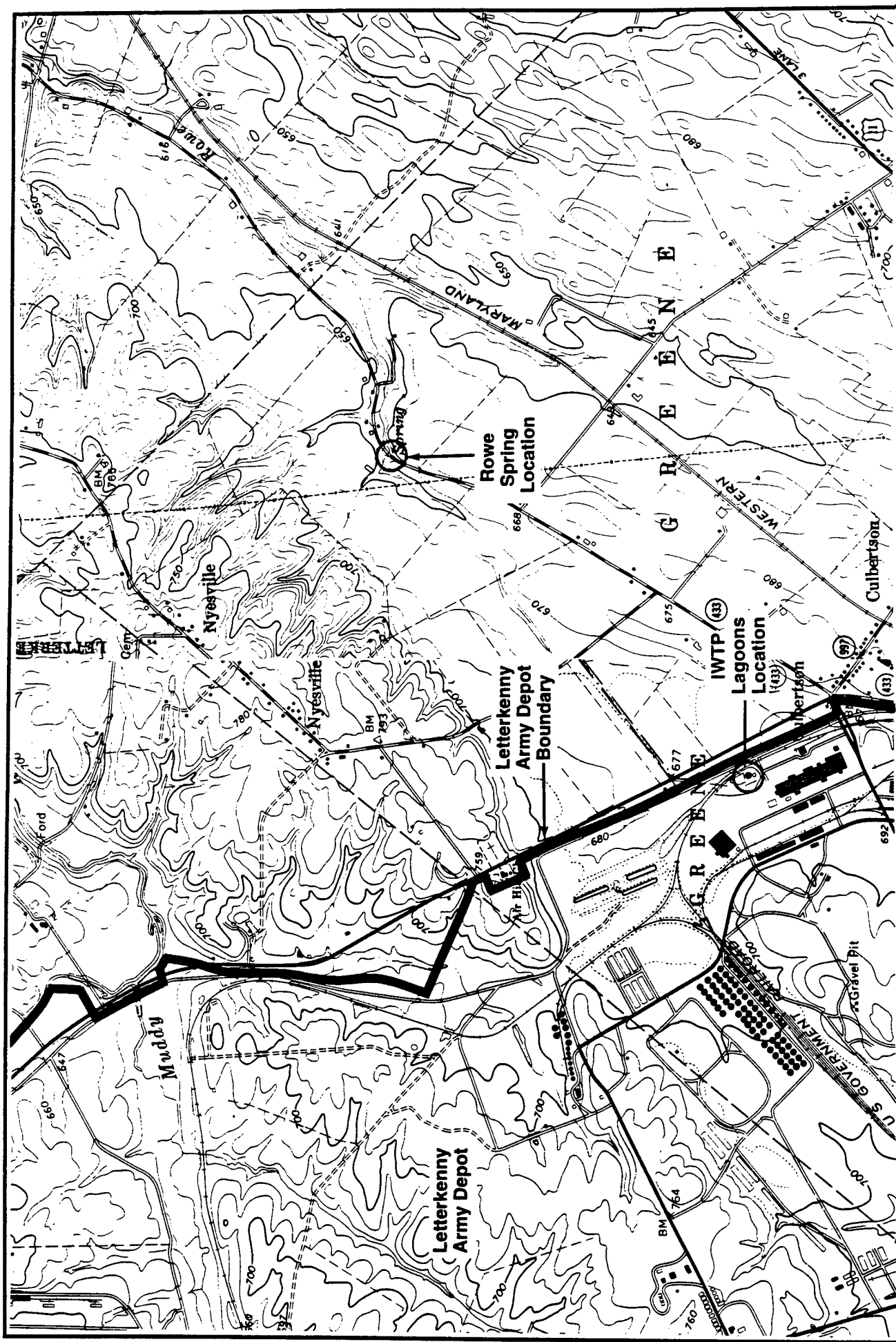


FIGURE 1-1 SITE LOCATION MAP

**SOURCE: U.S.G.S. 7.5 Minute Series
Foxbury and Shippensburg Quadrangles (1973)**

QUADRANGLE LOCATIONS

1 MILE

SCALE

0 1 2

SECTION 2

SPRINGFLOW CHARACTERIZATION

2.1 FLOW CHARACTERIZATION

A study to determine the quantity of discharge from Rowe Spring was undertaken in October 1993. After initial attempts to directly measure flow from Rowe Spring using a weir were found to be ineffective, a new strategy was implemented. Environmental Science & Engineering, Inc. (ESE) installed stilling wells equipped with automatic data loggers upstream and downstream from Rowe Spring to measure the stage of Rowe Run at these locations. Periodically, velocity profiles were taken manually by both ESE and WESTON upstream and downstream of Rowe Spring to calculate the stream flow rate at both locations. These manual flow measurements were then paired with the corresponding stage measurements from ESE's data loggers to generate upstream and downstream rating curves.

Best fit regression lines were plotted on log/log paper to provide a method for equating stream flow rate with the automatic stage measurements. The calculated difference in flow between the upstream and downstream locations was assumed to be the flow rate of the spring. This method allowed indirect monitoring of the discharge from Rowe Spring for the period from 4 November 1993 through 4 November 1994. A summary of Rowe Spring discharge rates and springflow distributions is presented in Table 2-1 and is illustrated in Figure 2-1. From the data collected by ESE during this time, the average flow of Rowe Spring was determined to be approximately 700 gpm, with a maximum flow rate of just over 1,800 gpm.

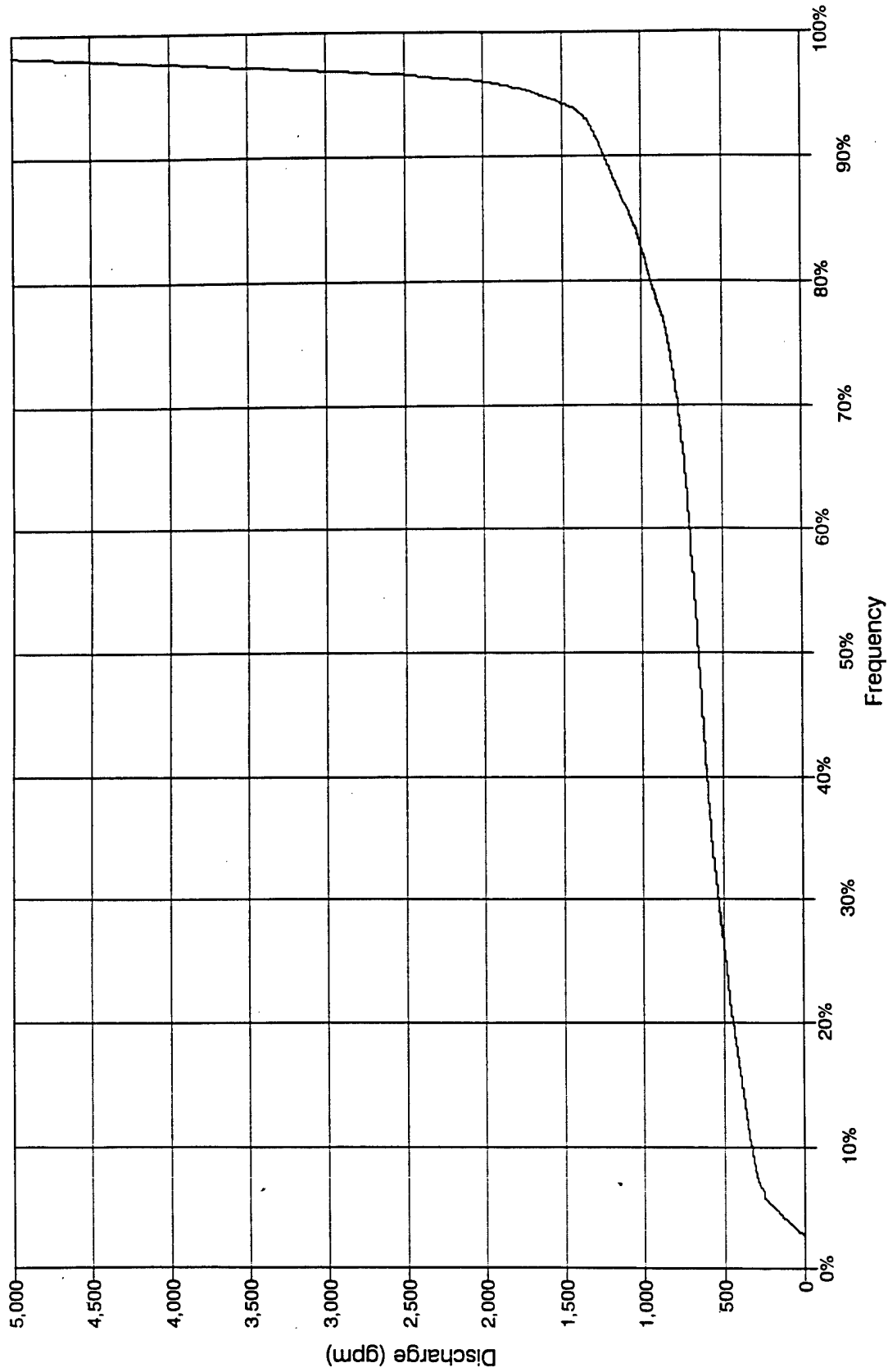
There is some degree of uncertainty associated with this measurement methodology because of surface runoff and channel storage effects between the upstream and downstream logging stations. During precipitation events, runoff of rainwater and/or snowmelt reaching Rowe Run between the two logging stations or at the other springs would be calculated as part of the spring discharge. For the long-term averages and peak flow estimates, the effects of

Table 2-1

Summary of Estimated Rowe Stream/Springflow Frequency Distributions
Period of Record: 11/4/93 to 11/4/94

Frequency	Rowe Spring: Hourly Discharge (DS01 - US01)	
	(cfs)	(gpm)
5%	0.40	180
10%	0.72	325
20%	0.99	442
30%	1.2	530
40%	1.3	600
50%	1.4	649
60%	1.6	700
70%	1.7	772
80%	2.1	941
90%	2.7	1,231
95%	3.7	1,648

Letterkenny Monitoring Data Estimated Rowe Spring Discharge



Source: Environmental Science & Engineering, Inc.
Memorandum Rowe Run Stream Flow and
Spring Flow Estimates 10 November 1994.

— Estimated Discharge — Appr 95% CI on Mean

96P-1558 5/3/96

FIGURE 2-1 ESTIMATED DISCHARGE OF ROWE SPRING

runoff and storage should be minimal. These values are adequate and conservative for design purposes.

2.2 CHEMICAL CHARACTERIZATION

Previous characterization (1982-1991) of the contamination in the Rowe Spring water resulted in the VOC concentrations presented in Table 2-2. The predominant contaminant in the spring water was trichloroethene (TCE), with concentrations ranging from a low of 31 parts per billion (ppb) to a high of 110 ppb. During the period between 4 October 1993 and 25 April 1996, 34 samples were collected from Rowe Spring and submitted to an analytical laboratory for volatile organic analyses. Sampling was conducted over two periods. During the first period, which extended from 4 October 1993 to 15 April 1994, samples were collected by WESTON. During the second period, which extended from 14 July 1994 to 25 April 1996, samples were collected by ESE. This sampling was performed to identify and quantify the current VOCs in Rowe Spring so that the amount of contaminant loading to the eventual treatment system could be determined. Table 2-3 presents the results of these sample analyses.

The results of these analyses indicate that the concentrations of VOCs in Rowe Spring are highly variable for some individual compounds. In addition, a few individual compounds were detected only a few times during the entire sampling program. Figure 2-2 presents a plot of total VOCs in each sample versus the spring discharge measured on that same day for the samples collected by WESTON in 1993 and 1994. Even though 12 samples were collected, only eight points have been plotted because on four of the days on which samples were collected, no flow measurements were able to be taken because of factors such as flooding, freezing, etc. For those VOCs which were not detected in certain samples, a zero value was used in the total VOC calculation. An inversely proportional relationship appears to exist between these parameters over the range plotted. These data indicate that at the higher Rowe Spring discharge rates the VOC concentrations in the emerging groundwater are diluted. It is theorized that this dilution occurs from precipitation percolating into the karst structure and being conveyed to the spring by solution cavities.

Table 2-2
Rowe Spring VOC Concentrations^a (1982-1991)

Sampling Date	Trichloroethene	1,2 Dichloroethene	Tetrachloroethene	1,1 Dichloroethane	1,1, Dichloroethene	1,1,1 Trichloroethane
15 July 1982	90	120	3.2	2.0	3.4	130
01 January 1983	62	ND ^c	ND	ND	ND	ND
20 February 1983	63	ND	ND	ND	ND	ND
11 May 1983	50	ND	1.3	ND	39	ND
24 October 1983	110	110	2.8	1.9	5.8	67
07 June 1991 ^b	49	97	2.3	1.2	1.9	26

^aAll concentrations in micrograms per liter.

^bDrought conditions.

^cND = Contaminant not detected.

Source: USAEC Installation Restoration Data Management Information System (IRDMIS).

Table 2-3
Rowe Spring VOC Concentrations (1993-1996)

DATE	Acetone	Chloroform	1,1-Dichloroethene	1,1-Dichloroethane	1,2-Dichloroethenes	1,1,1-Trichloroethane	Toluene	Trichloroethene	Methylene Chloride
4-Oct-93	<13.0	6.1	0.48	<0.68	42	10	<0.50	27	<2.3
17-Nov-93	<13.0	7.1	<0.50	<0.68	53	9.9	<0.50	30.4	<2.3
3-Dec-93	<13.0	1.8	<0.50	<0.68	27	4.5	<0.50	16	<2.3
15-Dec-93	<13.0	2.7	<0.50	<0.68	27	4.4	<0.50	14.2	<2.3
29-Dec-93	<13.0	1.6	<0.50	<0.68	33	6.1	<0.50	18.8	<2.3
18-Jan-94	<13.0	3.2	1.06	<0.68	40	8.1	<0.50	23.5	<2.3
26-Jan-94	<13.0	3.5	<0.50	<0.68	32	6.6	<0.50	19	<2.3
25-Feb-94	<13.0	1.0	<0.50	<0.68	34	4.9	<0.50	16	<2.3
4-Mar-94	<13.0	1.1	<0.50	<0.68	37	6.2	<0.50	19.6	<2.3
17-Mar-94	<13.0	<0.50	<0.50	<0.68	7.7	0.85	<0.50	4.47	<2.3
1-Apr-94	<13.0	<0.50	<0.50	<0.68	5.7	0.93	<0.50	3.97	<2.3
15-Apr-94	<13.0	<0.50	<0.50	<0.68	14	2.7	<0.50	8.29	<2.3
14-Jul-94	<13.0	6.0	<0.50	<0.68	31	8.4	<0.50	18.8	<2.3
31-Aug-94	<13.0	4.9	<0.50	<0.68	33	6.6	<0.50	21.6	<2.3
23-Sep-94	<13.0	8.8	<0.50	<0.68	29	6.8	<0.50	20.9	<2.3
28-Oct-94	<13.0	14.0	<0.50	<0.68	38	8.2	1.16	23.9	<2.3
3-Nov-94	<13.0	13.0	<0.50	<0.68	26	5.8	<0.50	17.6	<2.3
9-Dec-94	<13.0	2.0	<0.50	<0.68	25	4.4	<0.50	15.5	4.4
3-Jan-95	<13.0	3.0	<0.50	<0.68	34	6.3	<0.50	21	<2.3
3-Feb-95	28.0	1.7	<0.50	<0.68	30	5.5	<0.50	17.3	<2.3
29-Mar-95	<13.0	4.7	<0.50	0.90	36	10	<0.50	27.8	<2.3
4-Apr-95	<13.0	4.7	<0.50	0.70	32	9.2	<0.50	23.3	3.5
18-May-95	<13.0	5.5	<0.50	<0.68	34	7.2	<0.50	21.5	<2.3
22-Jun-95	<13.0	6.1	<0.50	0.69	50	7	<0.50	29.9	2.3
27-Jul-95	<13.0	3.9	<0.50	<0.68	39	5.9	<0.50	23.1	<2.3
29-Aug-95	<13.0	9.1	<0.50	<0.68	48	6.6	<0.50	27.1	<2.3
26-Sep-95	<13.0	10	<0.50	0.77	55	7.9	<0.50	32.8	<2.3
25-Oct-95	<13.0	7	<0.50	<0.68	36	8.7	<0.50	29.2	<2.3
15-Nov-95	<13.0	5.3	<0.50	<0.68	31	8.6	<0.50	25	<2.3
14-Dec-95	<13.0	4.5	<0.50	<0.68	56	<0.50	<0.50	44.3	<2.3
17-Jan-96	<13.0	2.2	<0.50	0.69	62	9.6	<0.50	45.3	<2.3
13-Feb-96	<13.0	0.54	<0.50	<0.68	16	3.2	<0.50	12.9	<2.3
17-Mar-96	<13.0	0.57	<0.50	<0.68	24	5.9	<0.50	19.3	<2.3
25-Apr-96	<13.0	0.61	<0.50	<0.68	35	7.4	<0.50	23.2	<2.3

All values are in micrograms per liter.

Table 2-3

Rowe Spring VOC Concentrations (1993-1996)

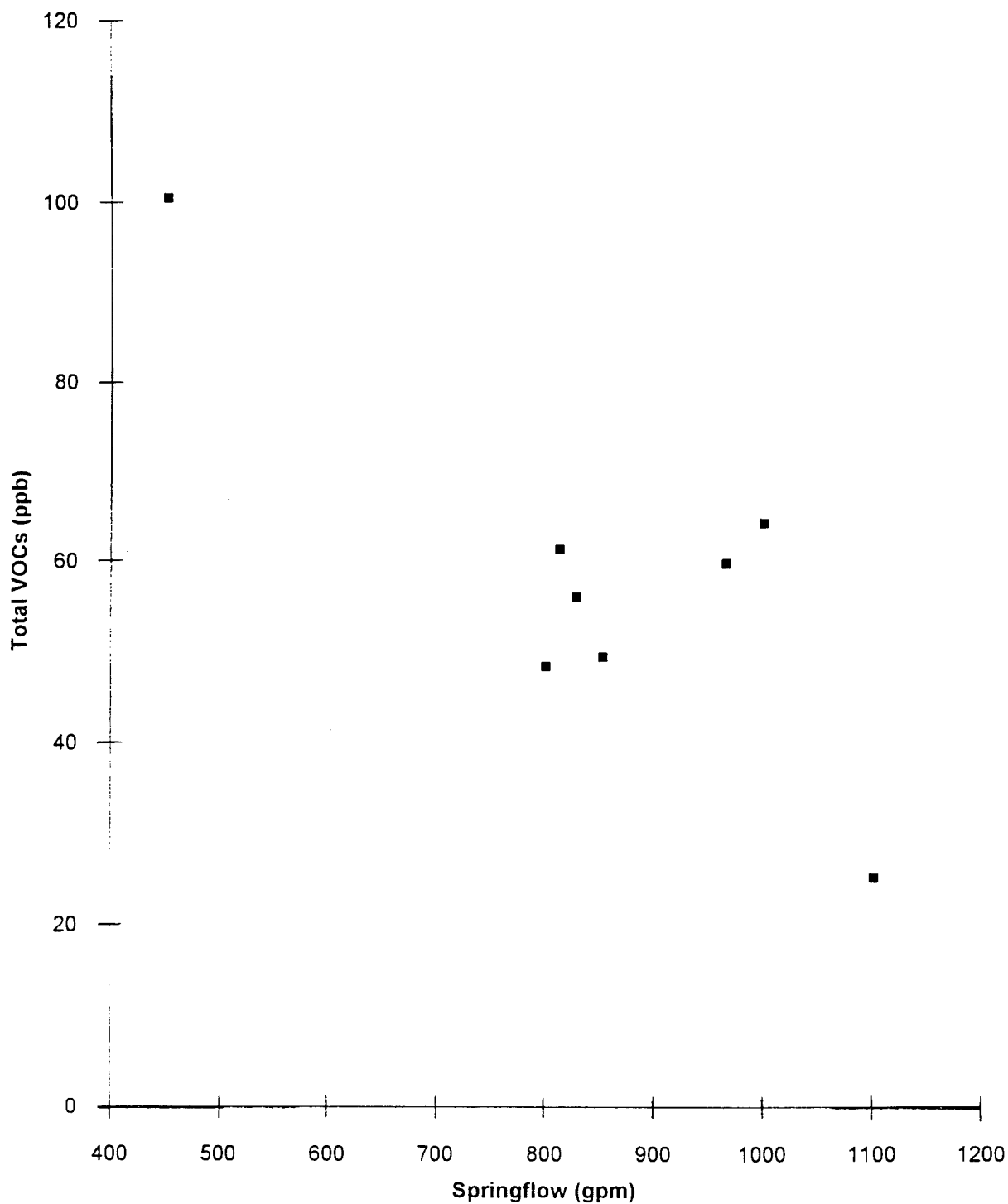
The following compounds were also analyzed but were not detected in any of the samples collected.
The lower detection limit for each analyte measured in micrograms per liter is presented in parentheses.

Benzene (0.50)	trans-1,3-Dichloropropene (0.70)
Bromodichloromethane (0.59)	Ethylbenzene (0.50)
Bromoform (2.6)	Methyl n-butyl ketone (3.6)
Bromomethane (5.8)	Dichloromethane (2.3)
Methyl ethyl ketone (6.4)	Methyl isobutyl ketone (3.0)
Carbon disulfide (0.50)	Styrene (0.50)
Carbon tetrachloride (0.58)	Tetrachloroethane (0.51)
Chlorobenzene (0.50)	Tetrachloroethene (1.6)
Chloroethane (1.9)	1,1,2-Trichloroethane (1.2)
2-Chloroethyl vinyl ether (0.71)	Trichlorofluoromethane (1.4)
Chloromethane (3.2)	Vinyl acetate (8.3)
Dibromochloromethane (0.67)	Vinyl chloride (2.6)
1,1-Dichloroethane (0.68)	Xylenes (0.84)
1,2-Dichloroethane (0.50)	Acrolein (100)
1,2-Dichloropropane (0.50)	Acrylonitrile (100)
cis-1,3-Dichloropropene (0.58)	

2-7

Figure 2-2

Total VOC Concentration vs. Springflow at Rowe Spring





SECTION 3

DESIGN CRITERIA

3.1 EFFLUENT PERMIT CONDITIONS

The proposed groundwater remediation system will require a new National Pollutant Discharge Elimination System (NPDES) permit because it will result in a discharge to surface water. The discharge limitations contained in the NPDES permit will depend on the classification of the body of water receiving the discharge. In this case, the receiving water body will be Rowe Run, which is designated by the Pennsylvania Department of Environmental Protection (PADEP) as a cold water fishery. However, the discharge from the treatment facility will be returned to Rowe Run, which is used to water livestock. The groundwater treatment plant at LEAD currently operates under a discharge permit that requires it to produce a non-detectable discharge for several organic compounds. Therefore, the requirement for the proposed treatment facility is that it must produce a non-detectable discharge using USAEC Method UM20 (U.S. EPA Method 624) for the following contaminants: 1,1 dichloroethene; tetrachloroethene (PCE); cis 1,2-dichloroethene; trans 1,2 dichloroethene; vinyl chloride; trichloroethene (TCE); chloroform; methylene chloride; and 1,1,1-trichloroethane (TCA). In addition, the treatment facility must produce a discharge pH between 6.0 and 9.0 and the concentration of dissolved oxygen and nutrients must not adversely affect the receiving stream.

Several different discharge criteria are presented in Table 3-1, including the discharge limitations which the proposed treatment facility will have to meet.

3.2 AIR EMISSIONS PERMIT

The proposed treatment system may require an air pollution control permit from the PADEP Bureau of Air Quality Management (BAQM). However, because of the small quantity of volatiles being discharged and the rural location of the proposed facility, BAQM may allow the emission discharge without a permit. Because BAQM typically discourages

Table 3-1

Discharge Criteria and Maximum Concentrations for Volatiles Detected at Rowe Spring

Chemical Name	PP No.	CAS Number	Fish & Aquatic Life Criteria		Human Health Criteria (ug/L)	U.S. EPA 624 Detection Limit (ug/L)	Maximum Concentration Measured at Rowe Run (ug/L)	Date Observed
			Continuous (ug/L)	Maximum (ug/L)				
Chloroform	IIIV	00067663	389	1945	6 (CRL)	1.6	14.0	28 Oct 94
1,1-Dichloroethene*	16V	00075354	1492	7460	0.06 (CRL)	2.8	1.06	18 Jan 94
Methylene Chloride	21V	00074873	5500	27,500	N/A	N/A	4.4	9 Dec 94
Tetrachloroethene (PCE)	24V	00079016	450	2250	3 (CRL)	1.9	ND (1.6)	—
1,1,1-Trichloroethane	27V	00071556	605	3025	1000 (H)	3.8	10	4 Dec 93 29 Mar 95
Trichloroethene	29V	00079016	450	2250	3 (CRL)	1.9	45.3	17 Jan 96
Vinyl Chloride	31V	00075014	N/A	N/A	0.02 (CRL)	N/A	ND (2.6)	—

Notes:

CRL - Cancer Risk Level Criterion at 1.0×10^{-6} .

* - Trans and cis-1,2 dichloroethene reported together.

H - Threshold effect human health criteria.

NA - Not applicable.

ND - Not detected.

media-to-media exchange of contaminants (in this case water to air), it is anticipated that a Request for Determination (RFD) will be required, as a minimum. This RFD will include a description of abatement measures that will be implemented to prevent uncontrolled emissions and a plan for monitoring air discharges. After review of the RFD, a determination on the necessity of a permit will be made. The submission of an RFD is typically initiated during the detailed design of the facility.

3.3 OTHER PERMIT REQUIREMENTS

LEAD will have to obtain a Water Quality Management (WQM) Part II (Construction) permit from the PADEP BWQM prior to construction. The permit application package consists of the necessary application forms as well as a Design Engineer's Report that must be sealed by a Professional Engineer registered in the Commonwealth of Pennsylvania. The major items that have to be covered by the Design Engineer's Report include:

- General Information — A description of the proposed facility with layout diagram and schematic process flow diagram (PFD).
- Detailed description of the proposed treatment processes, including the design basis, chemical feed systems, pumps, and monitoring equipment.
- A description of the operational flexibility and reliability, such as alarms, effluent quality control, training, operation and maintenance (O&M) manuals, and site security.

3.4 RESIDENT CRITERIA

The resident criteria were established by USAEC to reduce or prevent adverse impacts on the surrounding human and animal populations. The following resident criteria will have to be met by the proposed treatment technology:

- **Background noise level contributed by the treatment technology.** The background noise level goal established by USAEC is 40 dbA or less for this location. The background noise level contributed by the treatment system also must not be harmful or attractive to livestock or pets.

- **Provide supply of treated water for livestock.** A portion of water from Rowe Spring is currently used to water livestock. The treatment system must supply, at a minimum, the same amount of water as is currently supplied by the base flow of Rowe Spring to allow for expansion of the user's farm operation. The water supplied to the livestock must meet Safe Drinking Water Act (SWDA) Maximum Contaminant Levels (MCLs) concerning chlorinated solvent contaminant concentrations (in the absence of animal standards for the ingestion of VOCs).
- **Compatibility with surroundings.** The treatment system must be either hidden from the view of residents or passing motorists, or must be compatible with existing nearby manmade structures.

3.5 OTHER CRITERIA

The following additional criteria were also considered in evaluating treatment technologies.

- **Cost Effectiveness.** The treatment technologies were evaluated based on their ability to meet all applicable discharge criteria and resident criteria for the lowest per unit treatment cost. The treatment systems were also evaluated for their ability to treat varying flow rates and influent contaminant concentrations in the most cost-effective manner. Operation and maintenance cost comparisons between treatment technologies were also performed.
- **Implementability.** The ease with which the treatment technology could be put into operation. Factors to consider here include permits required, utilities required, size of system, equipment type and availability, etc.
- **Maintenance Required.** Routine maintenance that must be performed to keep the technology operating at its maximum performance.
- **Suitability for Automation.** The ability of the treatment technology to be automated to reduce the amount of time spent by personnel at the site, and to record operating parameters.
- **Waste Generated.** The amount, type and nature of wastes generated, if any. Wastes generated would require appropriate disposal.
- **Current Availability.** Current use of the technology to treat VOCs in other applications and/or availability from vendors.



- **Service Life.** The length of time that the treatment technology is expected to be effective in meeting the treatment goals without major maintenance or replacement.
- **Hazardous Materials Storage On-site.** The need for hazardous materials storage on-site, such as treatment reagents.



SECTION 4

TECHNOLOGY SELECTION

A Technology Selection Report was submitted to USAEC in December 1994. The results of that selection process are summarized here. The Technology Selection Report is presented in its entirety as Appendix A.

A preliminary comparison of potentially applicable remedial alternatives was conducted (WESTON, 1994). Concurrent with this comparison, additional water sampling was performed to better define VOC concentrations in Rowe Spring. In addition, upstream and downstream flow measurements were taken by ESE to more accurately assess the discharge rate from Rowe Spring and to help develop a rating curve that would allow calculation of spring discharge based on electronically logged water level measurements.

From the original group of approximately 10 remedial alternatives, the focus was narrowed to the following three technologies, based on the unique constraints of the Rowe Spring site:

- Ultraviolet oxidation with hydrogen peroxide.
- Photocatalytic oxidation with titanium dioxide catalyst.
- Low-profile air stripping.

Each of these three technologies was evaluated in light of the most recent sampling results and the updated flow estimates. Based on capital and operating costs and the ability to function over a broad range of flows, the low-profile air stripping technology was selected for remediating the groundwater at Rowe Spring.

SECTION 5

CONCEPT DESIGN

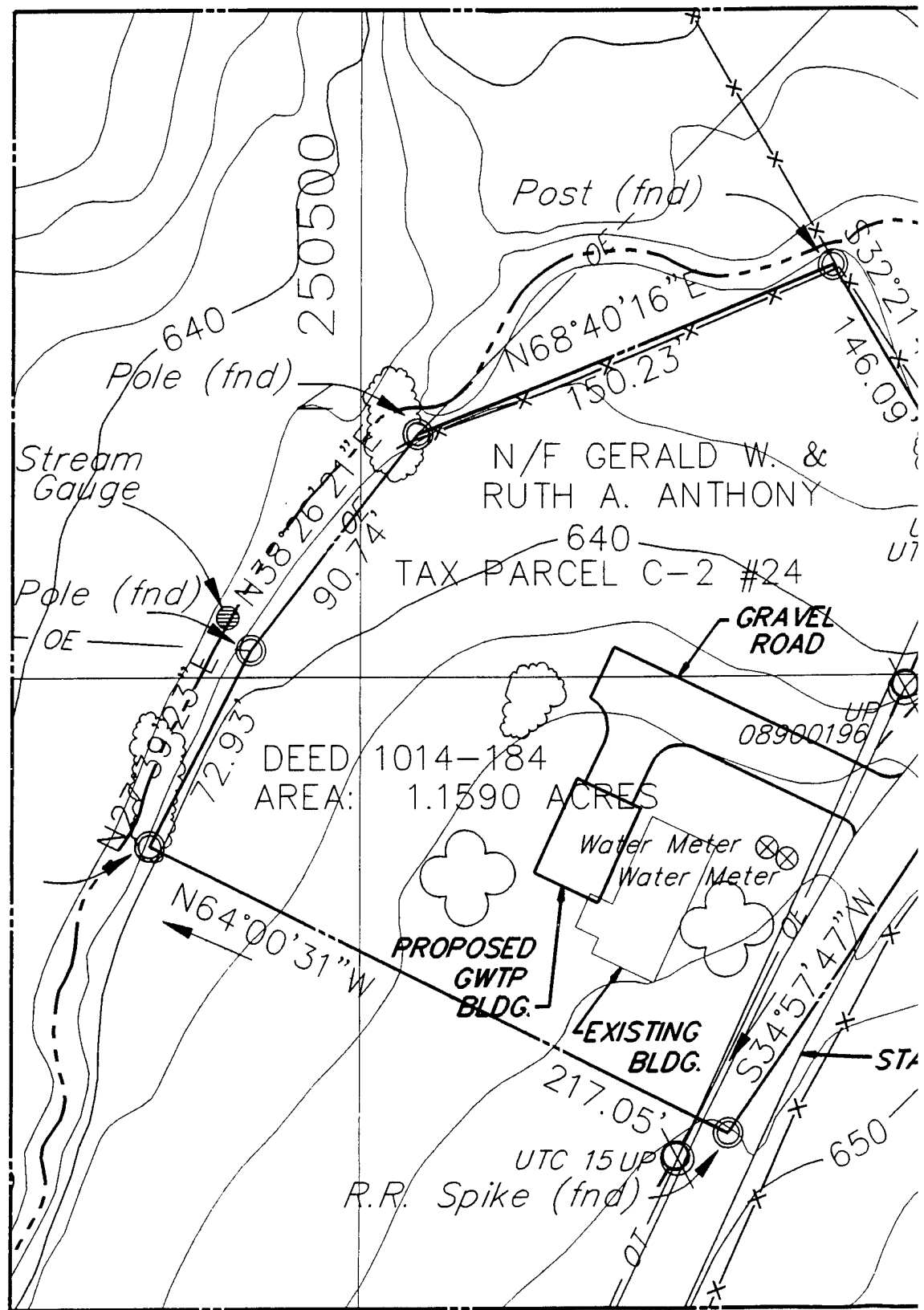
5.1 DESCRIPTION OF FACILITIES

A list of major components for the proposed facility is presented in Appendix B. The proposed groundwater remediation system consists of a low-profile air stripping system and associated groundwater collection, conveyance, and post-treatment redistribution systems. The selected air stripping system is a Maxi-Strip® Model 625 manufactured by Hazleton Environmental of Hazleton, Pennsylvania. The air stripping system will be located in a building measuring approximately 22 ft wide x 37 ft long x 11 ft high at the sides and 17 ft high in the center to be constructed in a field adjacent to Pennsylvania Route 433 approximately 200 ft west of Rowe Spring. The building would be typical of barns and other outbuildings of the farms in the area. Access to the building would be via a dirt/gravel road. Figure 5-1 shows the location of the proposed treatment plant building and access to it. Figure 5-2 is a rendering of the appearance of the finished building.

A process flow diagram for the proposed facility is presented in Figure 5-3. A legend of appropriate mechanical components and instrumentation is presented in Figure 5-4.

The springbox will need to be demolished and rebuilt. The new springbox will consist of two compartments, one for withdrawal of groundwater and one for return of treated water. The compartments will be separated by a baffle that will extend to the top of the compartment. An overflow pipe has been provided in this compartment that will allow raw groundwater to overflow to the stream in the event of excessively high spring discharge rates or in the event of power outages. The springbox will be covered by a small structure, built to resemble a typical springhouse. An artist's rendering of this structure is provided in Figure 5-5. This structure will protect the mechanical and electrical components of the withdrawal system. In addition, it will be built using construction materials that will minimize the transmission of noise generated by the withdrawal pumps.

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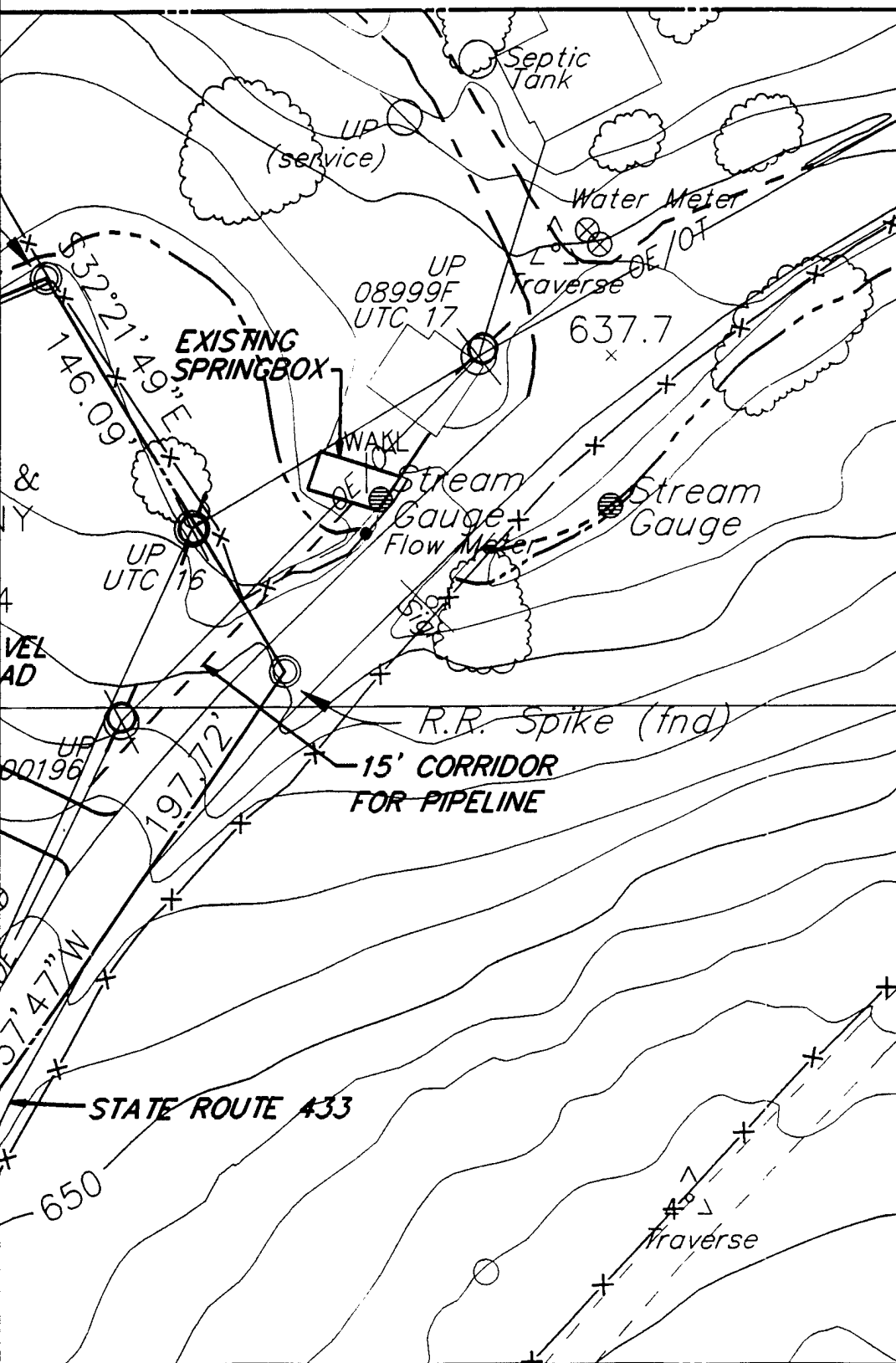


FIGURE 5-1
 ROWE SPRING
 PROPOSED LOCATION OF
 TREATMENT FACILITY



DRAWN	LJC	DATE	3/19/96	DES. ENG.	DATE	W. O. NO.	02281-012-003
CHECKED		DATE		APPROVED	DATE	DWG. NO.	

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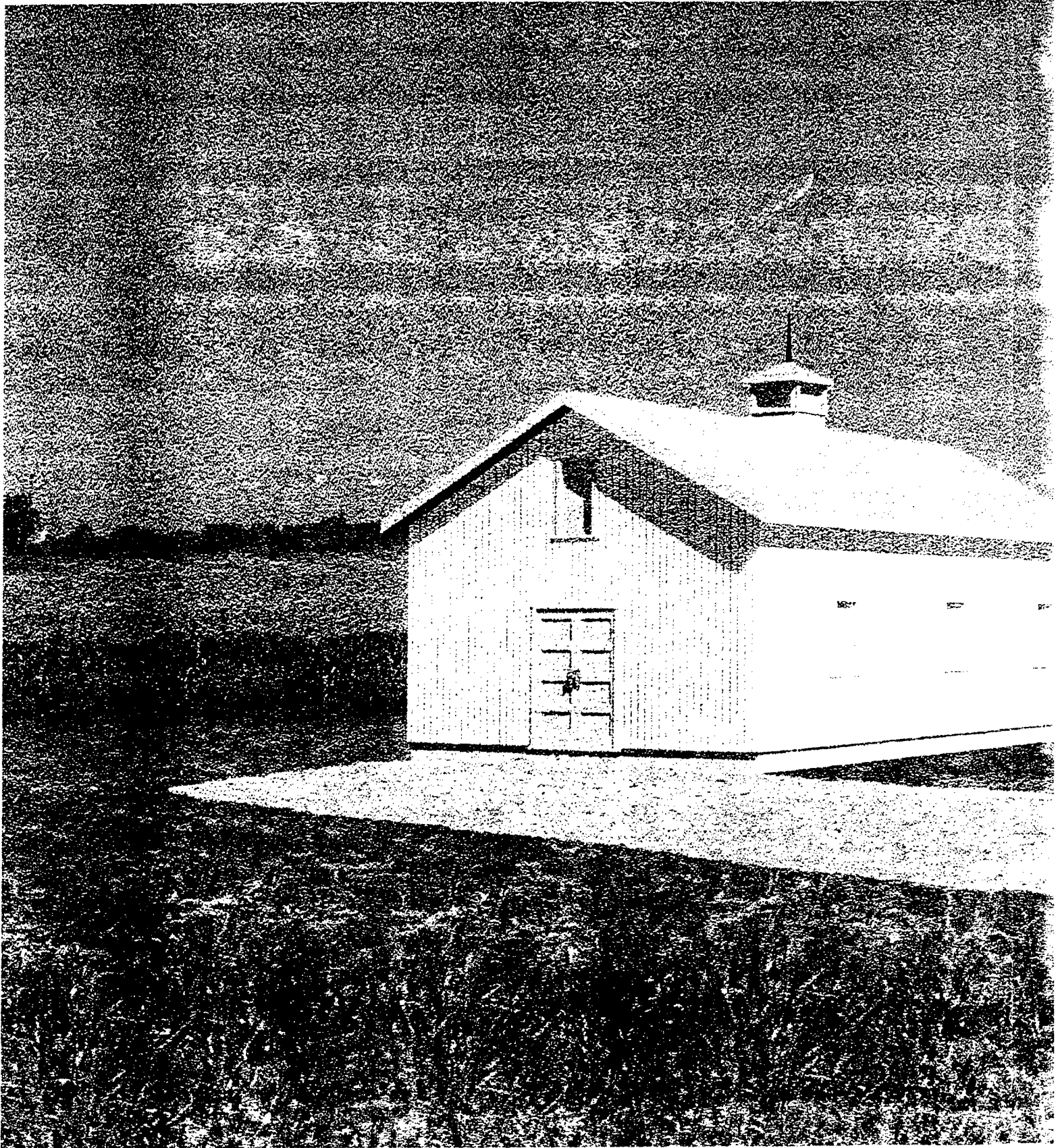


FIGURE 5-2 ARTIST'S RENDERING OF

(2)



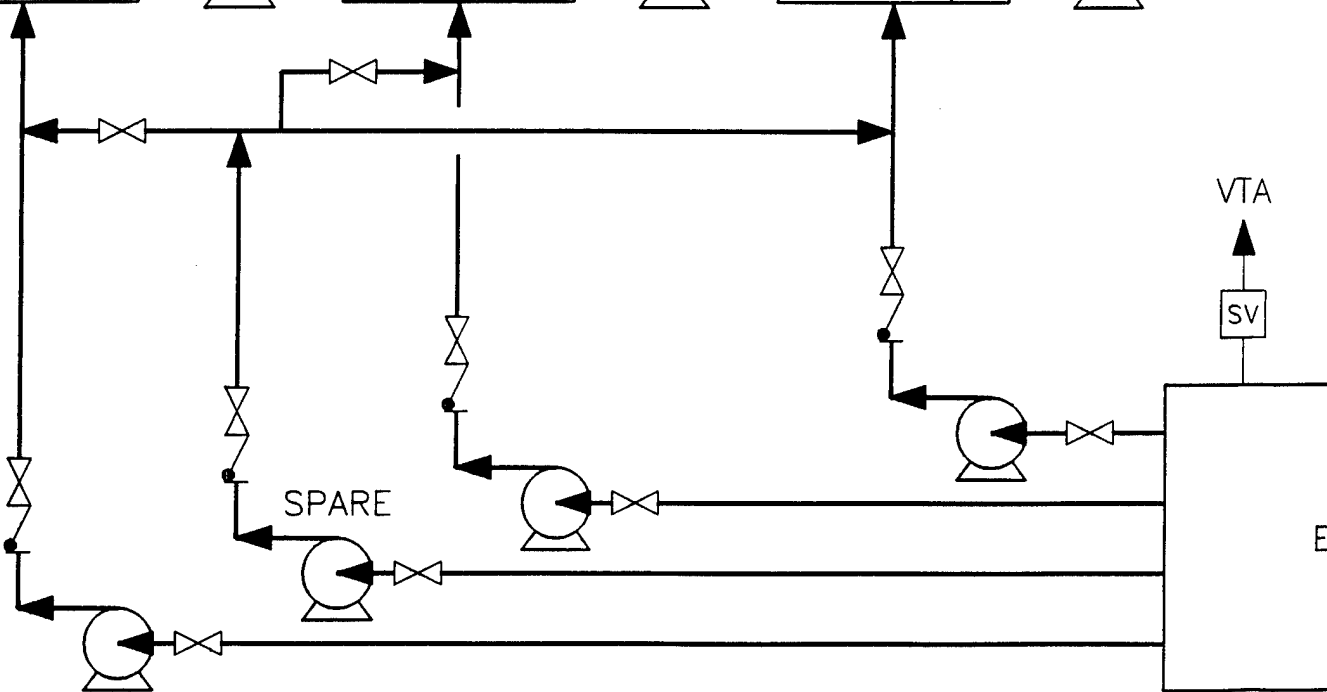
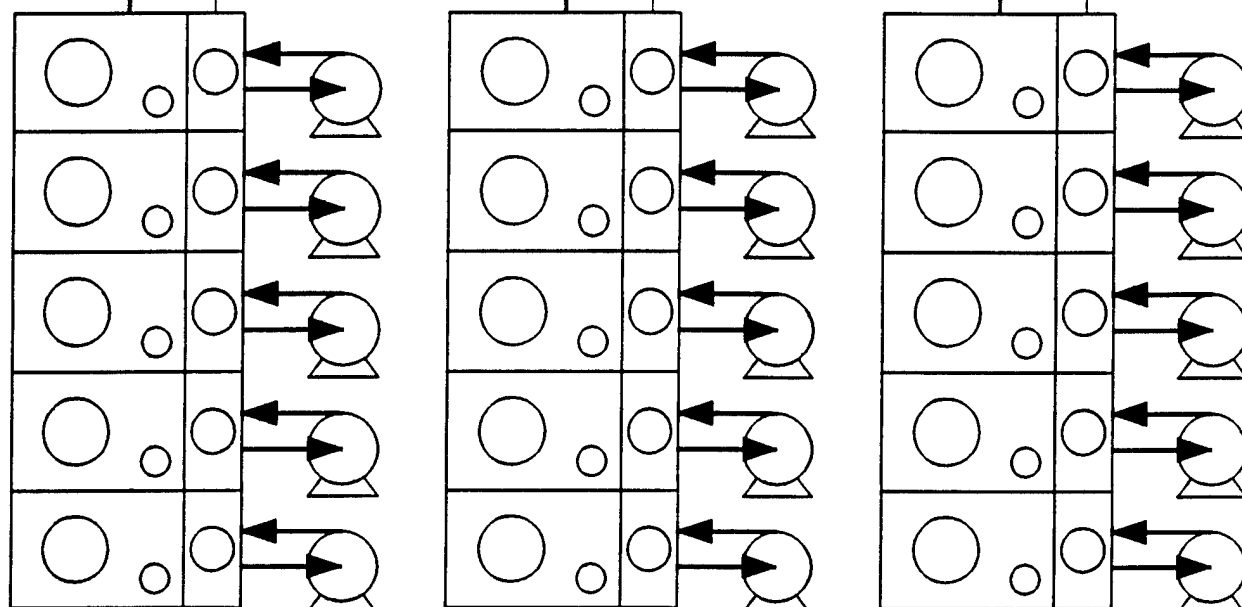
NG OF TREATMENT FACILITY BUILDING

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OFFGAS

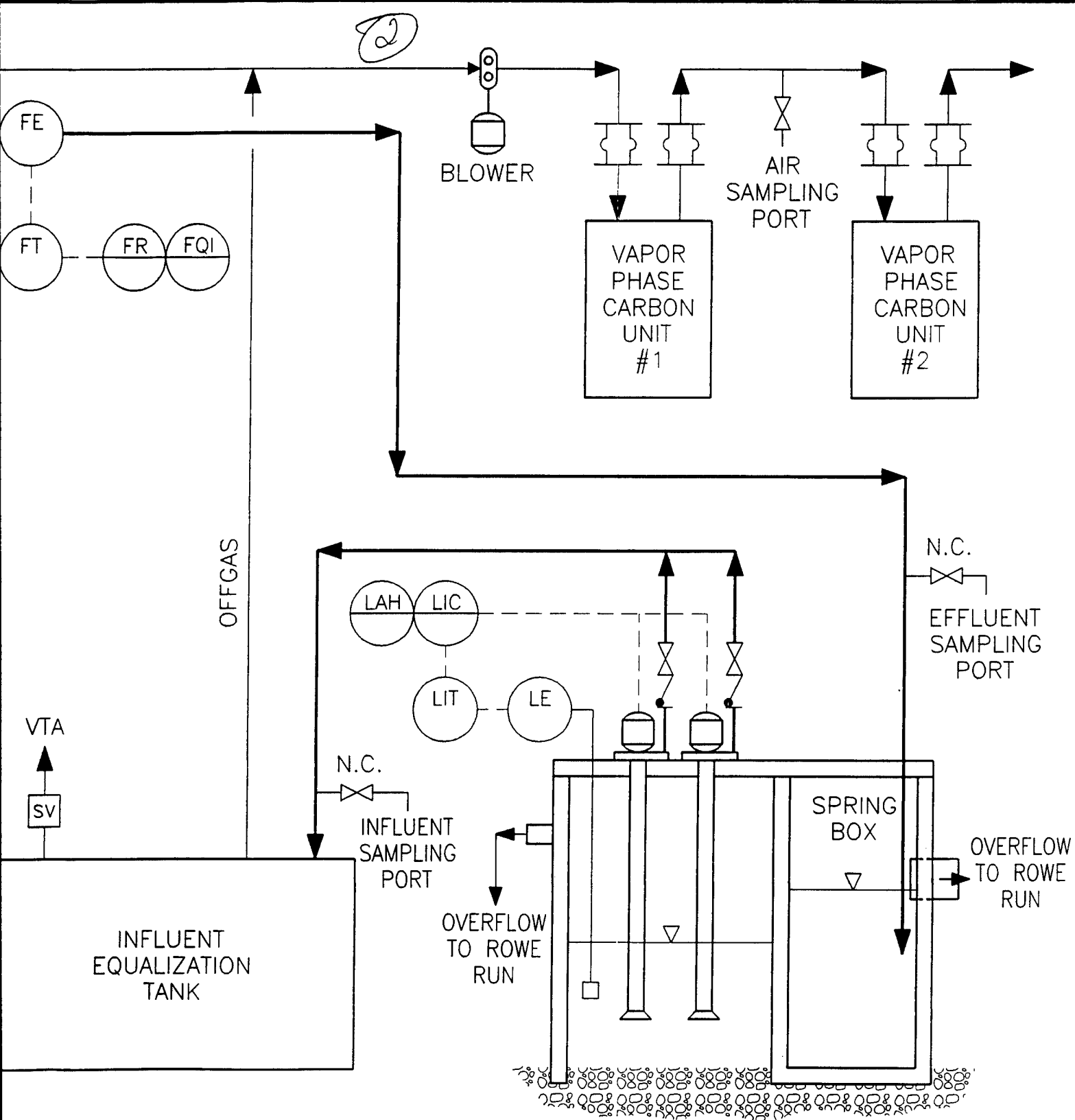
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**FIGURE 5-3
ROWE SPRING PROPOSED
GROUNDWATER
TREATMENT PLANT
PROCESS FLOW DIAGRAM**



ROY F. WESTON, INC.
WESTON
MANAGERS DESIGNERS/CONSULTANTS

DRAWN	MJP	DATE	5/3/96	DES. ENG.	DATE	W. O. NO.	02281012003
CHECKED		DATE		APPROVED	DATE	DWG. NO.	1001

LINES

	PROCESS LINE
	SECONDARY PROCESS LINE
	ELECTRICAL LINE

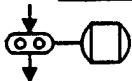
VALVE BODIES

	GATE VALVE
	SWING CHECK VALVE

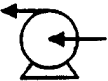
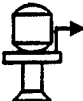
PIPING

	FLEXIBLE CONNECTION
---	---------------------

AIR MOVING EQUIPMENT

	POSITIVE DISPLACEMENT BLOWER
--	------------------------------


PUMPS

	CENTRIFUGAL PUMP
	VERTICAL TURBINE PUMP

FLOW ELEMENTS

	FLOW ELEMENT (* SIZE IN INCHES)
---	----------------------------------

INSTRUMENTS & ELECT DESIGNATIONS

	NOTE 2 INSTRUMENT-LOCALLY NOTE 1
---	--

	INSTRUMENT-BOARD MOL
---	----------------------

	INSTRUMENT-DUAL EL SINGLE
---	------------------------------

ABBREVIATIONS

A.S.	INSTRUMENT AIR SUPPLY
N.C.	VALVE NORMALLY CLOSED
N.O.	VALVE NORMALLY OPEN
F.O.	FAIL OPEN
F.C.	FAIL CLOSED
F.P.H.	FREEZE PROOF HYDRANT
S.T.	SAMPLE TAP

05/06/96 11:47 am

ROWE
C
TREATI
FOR PRO

ELECTRICAL IONS

LOCALLY MOUNTED

ARD MOUNTED (MAIN PANEL)

UAL ELEMENT IN
INGLE CLOSURE

IONS

UPPLY

CLOSED


OPEN

DRANT

INSTRUMENT TERMINOLOGY

UPPER CASE LETTER	FIRST LETTER PROCESS VARIABLE	MODIFIER (Δ)OR SECOND LETTER TYPE READING OR FUNCTION	THIRD/ FOURTH LETTER FUNCTION
A	ANALYZER (NOTE 1)	ALARM	ALARM
B	BURNER FLAME	-	-
C	CONDUCTIMTY	CONTROL/ CONTROLLER	CONTROLLER
D	DENSITY	DIFFERENTIAL(Δ)	DISC
E	ELECTRICAL (EMF)	ELEMENT	ELEMENT
F	FLOW RATE	RATIO (FRACTION) (Δ)	-
G	-	GLASS	GLASS
H	HAND	HAND	HIGH
I	CURRENT (ELECTRICAL)	INDICATING/ INDICATOR	INDICATOR
J	POWER	SCAN (Δ)	-
K	TIME	-	-
L	LEVEL	LIGHT (PILOT)	LOW
M	MOISTURE (HUMIDITY)	-	-
N	-	-	-
O	OPERATION	ORIFICE	-
P	PRESSURE/VACUUM	PRESSURE	-
Q	QUANTITY	TOTALIZER (Δ)	-
R	RADIOACTIVITY	RECORDING/ RECORDER	RECORDER
S	SPEED/STOP	SWITCH(NOTE 5)	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTIFUNCTION	-	-
V	VISCOSITY	VALVE/DAMPER/ LOUVER	VALVE
W	WEIGHT	WELL	-
X	TORQUE	-	-
Y	-	RELAY (NOTE 2,5)	RELAY
Z	POSITION	DRIVE	-

FIGURE 5-4
OWE SPRING PROPOSED
GROUNDWATER
TREATMENT PLANT LEGEND
R PROCESS FLOW DIAGRAM

ROY F. WESTON, INC.				
				
MANAGERS		DESIGNERS/CONSULTANTS		
DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
MJP	5/3/96			02281012003
CHECKED	DATE	APPROVED	DATE	DWG. NO.
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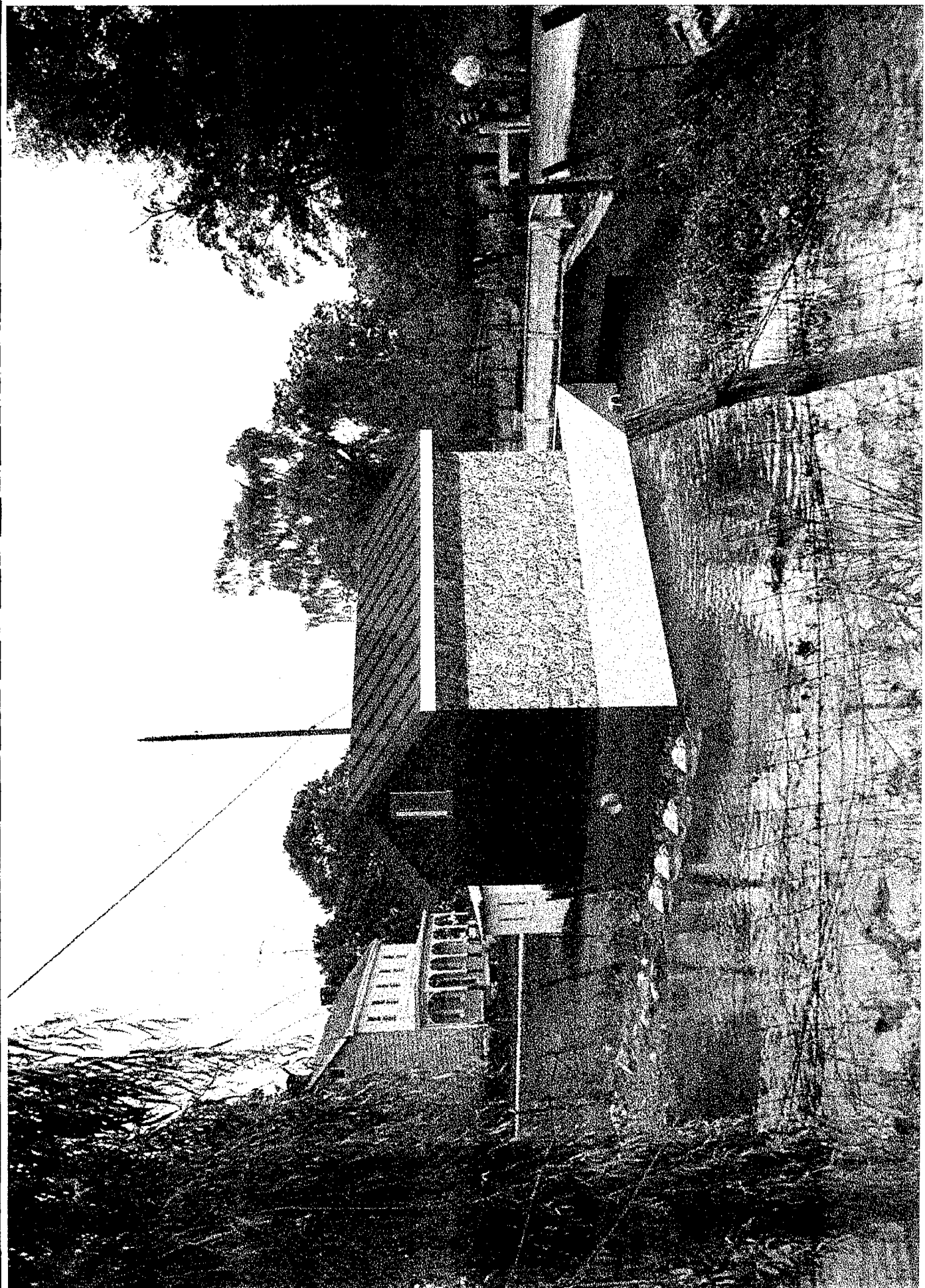


FIGURE 5-5 ARTIST'S RENDERING OF COLLECTION SYSTEM BUILDING

Water will be conveyed from the springbox to the main treatment facility by means of a buried pipeline. This pipeline will discharge to the influent equalization tank. A tap will be located just before the tank to provide a location to collect influent samples.

The influent equalization tank will be a 35,000-gallon concrete tank located in the base of the treatment building. It will be covered and vented to prevent the uncontrolled discharge of fugitive VOC emissions. The tank will act as a clearwell, storing raw groundwater until it can be treated by the air stripping system. This level of water in this tank will also control the operation of both the air stripping system and the withdrawal system.

The air stripping system will consist of three parallel trains of five module Model 625 Maxi-Strip units. The Maxi-Strip system was selected over other air stripping technologies for the following reasons:

- Ability to handle suspended solids
- Low maintenance
- Low noise level during operation

Based on an average influent flow of 700 gpm, the influent flow will be split so that under normal conditions each of the first two trains will receive 350 gpm of flow. The flow to each train can be increased to a maximum of 500 gpm; therefore, at a maximum flow of 1,500 gpm all three trains would be operating. Vendor information for the Maxi-Strip systems is provided in Appendix C.

To achieve a greater degree of contaminant removal than can be achieved with the individual components alone, each individual unit will be configured in series with four other units within a given train.

The treated water will flow by gravity back to the discharge compartment of the springbox, where it will ultimately be discharged to Rowe Run.

All offgases from the Maxi-Strip units and the equalization tank will be ducted to a positive displacement blower, which will then convey this gas to two vapor-phase carbon units arranged in series. The positive displacement blower increases the temperature of the offgas, thereby eliminating the need for a separate heating unit to reduce the moisture in the gas stream. The carbon units are arranged in series so that any breakthrough that occurs in the first unit will be controlled by the second unit. When breakthrough does occur in the first unit, the unit will be taken out of service and the carbon removed and taken off-site for regeneration. The second unit will then be moved to the first position and a new unit placed in the second position.

A geotechnical investigation was performed during January 1996 to explore the subsurface conditions at the site and to formulate recommendations for the design and construction of the foundation system. The Geotechnical Investigation Report is presented in Appendix D.

5.2 THEORY OF OPERATION

The proposed groundwater treatment facility will be fully automatic and will require very little operator attention. The majority of operational parameters will be controlled by the process instrumentation. For example, the operation of the withdrawal pumps will be controlled by the level of water in the springbox. When the level of water falls below a certain level, the pumps will turn off, allowing the water level to recover. When the level is higher than normal, both pumps will operate and more water will be pumped to the treatment facility. Likewise, the operation of the air stripping system will be controlled by the level of water in the influent equalization tank.

Some operation attention will be needed for maintenance of the various mechanical components, such as lubrication. In addition, an autodialer alarm system will be installed to alert the operator in case of a malfunction.

5.3 COST ESTIMATE

Estimated capital costs have been prepared for the proposed treatment facility and are presented in Table 5-1. These cost estimates are considered conceptual level ($\pm 30\%$) and do not account for special site conditions such as rock excavation, etc. In addition, permitting and land acquisition costs have not been included.

Table 5-1

Summary of Capital Costs

Springbox Modifications	\$22,240
Withdrawal Pumps	20,000
Conveyance and Discharge Piping	6,000
Treatment Building	71,700
Air Stripping Components	422,000
Influent Pumps	18,000
Blower	4,900
Carbon	<u>50,000</u>
Subtotal	\$614,840
Piping (at 12%)	\$73,780
Electrical (at 15%)	92,226
Instrumentation (at 8%)	49,187
Site Work (at 5%)	<u>30,742</u>
Subtotal	\$245,935
Contingency (at 15%)	\$129,120
Design Engineering (at 10%)	<u>86,000</u>
Subtotal	\$215,120
TOTAL CAPITAL COST	\$1,075,895



APPENDIX A

TECHNOLOGY SELECTION REPORT



**U.S. ARMY ENVIRONMENTAL CENTER (USAEC) DEMONSTRATION OFF POST
GROUNDWATER TREATMENT PLANT
(ROWE, WIRTH, DOZENS, HAWBACKER, AND HELMAN SPRINGS)**

**Technology Selection Report
13 December 1994**

Introduction/Background:

As part of the installation restoration activities being performed at Letterkenny Army Depot (LEAD), USAEC is currently addressing groundwater contamination at several off-post springs which contribute to the base flow of a nearby surface stream referred to as Rowe Run. In the mid 1960's, the development of a sinkhole in a lagoon at the industrial waste treatment plant (IWTP) at LEAD released industrial wastewater containing volatile organic compounds (VOCs) into the groundwater. These lagoons have subsequently been removed from service and closed in accordance with RCRA requirements. VOCs have been detected in water samples collected at Rowe, Wirth, Hawbacker, Helman and Helman East Springs.

Based on an initial flow estimate of 100 gallons per minute (gpm), and using limited analytical data from seven samples collected between 1982 and 1991, a comparison of potentially applicable remedial alternatives was conducted. Concurrent with this comparison, additional water sampling was performed to better define the current VOC concentrations in Rowe Spring. Also, upstream and downstream flow measurements were taken to more accurately assess the discharge rate from Rowe Spring and to help develop a rating curve which would allow calculation of spring discharge based on electronically logged water level measurements. During this period, three additional springs were identified downstream from Rowe Spring. These springs have been identified as Helman Springs (East and West) and the Wirth Spring. The discharge rates of these springs were also estimated.

From the original group of approximately ten remedial alternatives, the focus was narrowed to the most promising three technologies based on the unique constraints of the Rowe Spring site. Each of these three technologies were evaluated in light of the most recent

sampling results and the updated flow estimates. This report presents the results of this evaluation and presents estimated costs for implementation of each alternative.

Spring Characterization Results:

Flow Measurement:

After initial attempts to directly measure flow from Rowe Spring using a weir were found to be ineffective, a new strategy was implemented. Environmental Science and Engineering (ESE) installed stilling wells equipped with automatic data loggers upstream and downstream from Rowe Spring to measure the stage of Rowe Run at these locations. Periodically, velocity profiles were taken manually by both ESE and WESTON upstream and downstream of Rowe Spring to calculate the stream flow rate at both locations. These manual flow measurements were then paired with the corresponding stage measurements from ESE's data loggers to generate upstream and downstream rating curves.

Best fit regression lines were plotted on log/log paper to provide a method for equating stream flow rate with the automatic stage measurements. The calculated difference in flow between the upstream and downstream locations was assumed to be the flow rate of the spring. This method allowed indirect monitoring of the discharge from Rowe Spring for the period from 04 November 1993 through 02 November 1994. From the data collected by ESE during this time, the average flow of Rowe Spring was determined to be approximately 700 gpm, with a maximum flow rate of just over 1800 gpm. When the data collected by a similar method from Helman, Helman East, and Wirth Springs is included, the combined peak flow estimate for all four springs is 3500 gpm.

There is some degree of uncertainty associated with this measurement methodology due to surface runoff and channel storage effects between the upstream and downstream logging stations. During precipitation events runoff of rainwater and/or snowmelt reaching Rowe Run between the two logging stations or at the other springs would be calculated as part of the spring discharge. Temporary storage (pooling) of water during such events would also affect the spring discharge calculations. Consequently, the hourly spring discharge estimates

should not be used directly for calculation or design. However, for the long term averages and peak flow estimates, the affects of runoff and storage should be minimal. These values are adequate and conservative for design purposes.

Chemical Characterization:

During the period between 04 October 1993 and 15 April 1994, twelve samples were collected from Rowe Spring and submitted to an analytical laboratory for volatile organic analyses. This sampling was performed to identify and quantify the current VOCs in Rowe Spring so that the degree of contaminant removal required by the eventual treatment system could be determined. Table 1 presents the results of these sample analyses. Additional sampling of the two Helman Springs and Wirth Spring has recently been conducted by ESE and the results should soon be available.

The results of these analyses indicated that the current concentrations of VOCs in Rowe Spring have decreased relative to the levels measured in samples collected between 1982 and 1993. In addition, Figure 1 plots total VOCs as measured in each sample versus the spring discharge measured on that same day. For those VOCs which were not detected in certain samples, a zero value was used in the total VOC calculation. An inversely proportional relationship appears to exist between these parameters over the range plotted. This would seem to indicate that at the higher discharge rates associated with precipitation events, there are dilution effects on the VOC concentrations of the emerging groundwater. If this relationship can be further quantified with additional data points, it may be possible to reduce the amount of equipment necessary in the full-scale design to treat the peak flow.

Evaluation of Technologies:

The initial screening of technologies potentially applicable to treatment of water at Rowe Spring limited the focus of the alternative selection to three types of systems:

- Ultraviolet Oxidation with Hydrogen Peroxide
- Photocatalytic Oxidation with TiO_2 Catalyst

- Low-Profile Air Stripping with Emissions Controls

These alternatives were selected based on their ability to meet the emissions requirements and the unique residential criteria set by USAEC. Relative to other alternatives, these three technologies appeared to present the most cost-effective solutions to the VOC contamination at Rowe Spring. However, at the time the alternatives were screened, the most recent spring characterization activities had not been completed. The original screening considered a design flow rate of 100 gpm, which has since been replaced with an estimated average flow of 700. Additionally, the inclusion of Wirth and Helman Springs has increased the potential peak flow to over 3000 gpm. As a result, some of the original alternatives which were eliminated based on the previous spring conditions may need to be reconsidered to ensure that the three technologies selected for further evaluation are still the most promising.

In the following sections, a description of each alternative is provided along with discussion of the advantages and disadvantages associated with each. Implementation issues are discussed for each in light of the updated flow estimates and recently measured VOC concentrations. For each alternative, one or more vendors were contacted to provide estimates of capital and operational costs. These costs have been presented, along with present worth values to provide a comparison among technologies.

Ultraviolet Oxidation:

Advanced Oxidation Processes (AOPs), also referred to as "ultraviolet oxidation," have been commercially available for over ten years. These systems combine oxidizing agents such as hydrogen peroxide with an aqueous waste stream containing organic compounds. In the presence of ultraviolet light, the formation of highly reactive hydroxyl radicals from the hydrogen peroxide initiates the oxidation of the target organics. Each compound follows different oxidative pathways, but ultimately the end products of the reaction are innocuous organic acids, carbon dioxide, and salts. By this process, the organic contaminants are completely destroyed and there is no need for residuals disposal.

There have been significant improvements in advanced oxidation systems since they were first introduced. One major difficulty that has been overcome is the formation of light-blocking iron oxide scale on the surfaces of the quartz sleeves surrounding the ultraviolet lamps. In the first generation systems, this scale dramatically reduced the efficiency of the systems, and made it necessary to either manually clean the quartz sleeves quite frequently and/or over-design the capacity of system to compensate for this eventual reduction in efficiency. This problem has since been alleviated through the use of mechanical lamp cleaning devices which allow the removal of the scale without interrupting the treatment process. Most systems can also be equipped with programmable logic controllers (PLCs) to allow remote monitoring and control of the system functions.

Ultraviolet oxidation systems can provide reliable treatment when flow rates and contaminant concentrations remain relatively stable. When flow rates or concentrations increase beyond the design conditions, however, the system may provide only partial treatment. In such cases, both the target compounds and toxic intermediate by-products could appear in the effluent. Consequently, additional capacity must be built into the system to handle the peak flows and assure complete destruction of the target organics.

The application of ultraviolet oxidation at the Rowe Spring site would provide a neat, effective, and unobtrusive solution to the VOC contamination in the groundwater. The units are quiet, compact, and could easily be enclosed within a small building or underground vault (assuming the structural integrity of the site geology is sufficient). The operation of the system could be monitored remotely via the dial-up PLC. Operation and maintenance visits to the unit would be limited to lamp replacements, refilling of the hydrogen peroxide tanks, and infrequent equipment repairs. This alternative will create no waste residual and no air emissions.

Despite these apparent benefits of the ultraviolet oxidation process, its application to a flow of 700 gpm, let alone 3000 gpm is not common practice due to very high capital costs and energy consumption. Table 2 provides the cost estimates provided by Solarchem Environmental Systems of Markham, Ontario for a 700 gpm system with the capacity to

treat up to 3000 gpm. While operating at the average flow of 700 gpm the unit will require nearly 1 megawatt of electrical power, and during peak flow, could consume as much as 4 to 5 megawatts. The capital cost for a unit with this capacity is approximately \$12 million, and the annual operating costs which includes electrical power, lamp replacement, and hydrogen peroxide costs is \$950,000. For a 100 year life cycle assuming the equipment is replaced every 20 years, the present worth of this alternative is \$38 million.

Photocatalytic Oxidation with TiO_2 :

A potentially more cost effective, but less proven, technology for the treatment of VOCs in groundwater at Rowe Spring is photocatalytic oxidation. Like ultraviolet oxidation, the process is an oxidative process which completely destroys organic contaminants in aqueous streams. Unlike the conventional ultraviolet oxidation process, the photocatalytic process implements a titanium dioxide (TiO_2) catalyst to form the hydroxyl radicals. The catalyst can be suspended as a slurry in the water to be treated, or it can be fixed on a surface which the water passes over. Regardless of the state of the TiO_2 , in the presence of ultraviolet light, electrons are emitted from the catalyst and become available for oxidation reactions.

Similarly, the positively charged "holes" left by these electrons also become reaction sites. Ultimately, the reactions with both the "holes" and the electrons lead to the formation of hydroxyl radicals which in turn oxidatively destroy the target compounds.

The photocatalytic process is subject to the same advantages as ultraviolet oxidation, including quiet operation, compact profile, complete contaminant destruction, no generation of waste residuals, remote monitoring via PLC, no air emissions, and low maintenance requirements. Additionally, the photocatalytic process can be designed without the need for hydrogen peroxide addition, thus eliminating the need for onsite storage of hazardous materials and eliminating site visits to refill hydrogen peroxide tanks. Additionally, photocatalytic units generally consume less power than similar sized conventional ultraviolet oxidation systems.

Despite the advantages that the photocatalytic technology has over conventional ultraviolet oxidation, it is equally susceptible to large fluctuations in flow. As a result, the capacity of the system needs to be over-designed to handle peak flow situations, or else equalization tanks need to be included to temporarily store the water during peak events. Equalization tanks would not be feasible at Rowe Spring where the average flow of 700 gpm sometimes peaks to as high as 1800 gpm.

Cost estimates for a 700 gpm system with the capacity to treat up to 3000 gpm were provided by Purifics Environmental Technologies of London, Ontario. Capital costs for the system were estimated at \$5,340,000 with yearly operation and maintenance costs of \$195,000 which includes electrical power at an average of 200 kilowatts and lamp replacements. For a 100 year life-cycle at 5% interest with capital equipment replacements every 20 years, the present worth was calculated at \$12,400,000. These costs are presented in Table 3.

Air Stripping with Vapor-Phase Carbon:

Air stripping is the conventional technology for treating VOCs. Air strippers are typically configured in large towers containing porous packing materials over which the VOC-laden water flows by gravity. Simultaneously, air is blown countercurrently upward and in the process the VOCs, which have an affinity for the vapor phase, volatilize out of the water and are captured in the passing air stream. Once captured in the vapor phase, the VOCs can either be vented to the atmosphere or treated further, depending on the concentrations. If further treatment is required by regulatory agencies, VOCs in the vapor phase can be thermally incinerated, catalytically oxidized, or adsorbed to activated carbon.

For the compounds identified in the Rowe Spring water, air stripping is a very effective technology for removing the VOCs from the water. During the initial screening of alternatives, packed tower air strippers were eliminated due to their conspicuous dimensions and substantial blower noise. Instead, low profile air strippers were retained because of

their smaller size and the potential that the noise could be eliminated by placing them within a structure or underground vault.

Two types of low-profile air strippers have been investigated for potential application at Rowe Spring. The first is Shallow Tray strippers in which the springwater would be passed through a series of baffled aeration trays. Air is blown up through holes in the bottom of the trays forming a froth of bubbles which provide a large surface area for transfer of the VOCs to the vapor phase. The second type of stripper is the Maxi-Strip System manufactured by Hazleton Environmental. This low-profile air stripping technology implements turbulent jets of water to create large surface area, rather than packing material or trays. In addition, the jets are self-aspirating and, therefore, there is no need for noisy blowers.

The implementation of low profile air stripping at the Rowe Spring site could be complicated by a requirement for air emissions controls. Fortunately, the total mass of VOCs produced by the air stripper operating at the average flow of 700 gpm will be less than one pound per day. Vapor phase activated carbon would provide a simple method for treating these VOC air emissions. A 10 ft. diameter vessel filled with 8000 pounds of carbon would provide adequate capacity for five years of continuous operation. As a result, the operation and maintenance (power and repairs) for both systems are low. As a result, the total present worth values for the Shallow Tray and Maxi-Strip low profile air stripper systems are \$1,300,000 and \$1,800,000 respectively. Tables 4 and 5 summarize these present worth values.

Conclusion and Recommendation:

An evaluation matrix is presented in Table 6 as a tool for comparing and evaluating the three technologies retained for this alternative selection. All three technologies are effective for VOCs and could be implemented at the Rowe Spring site. However, there is a dramatic difference in cost among the three technologies that appears to favor the selection of low-profile air stripping technologies over ultraviolet and photocatalytic oxidation. The costs

presented are only for the treatment of the springwater. They do not include the costs of the springwater collection or transfer to the treatment plant, which are independent of the alternative selected, and which will be estimated after the contributions from the Wirth and Helman Springs have been finalized and the treatment plant location has been determined.

Ultraviolet oxidation would provide a reliable treatment alternative, but both the capital and O&M costs are prohibitive. In addition, this alternative will require the storage of hazardous materials onsite, including hydrogen peroxide and acids and bases for pH adjustments. Such storage is likely to be unacceptable to the property owners. Photocatalytic oxidation is an attractive alternative to ultraviolet oxidation because it would not require any onsite storage of chemicals, yet it would provide the same destructive treatment of VOCs without producing any residual wastes. Nevertheless, this alternative also has significant capital and operational costs associated with it.

Two different configurations of low-profile air strippers were evaluated in this selection process, Shallow Tray Air Strippers and Maxi-Strip Systems. Both systems would remove the VOCs from the springwater by transferring them to the vapor phase where they then would need to be removed by vapor phase activated carbon. Because the VOC concentrations measured in Rowe Spring are in the low parts per billion range, a single vapor phase carbon unit will have enough capacity for five years of continuous operation without requiring a carbon replacement. These low operation and maintenance costs coupled with relatively inexpensive capital equipment make low profile air strippers the best choice for Rowe Spring.

At this point, it would be difficult to make a definitive decision between the Shallow Tray and Maxi-Strip Systems. The Shallow-Tray system proved the least expensive alternative with a present worth of \$1.5 million, but there is also the issue of blower noise which needs to be addressed. The Maxi-Strip system was a close second in present worth at \$2.5 million, but it holds promise of being more quiet than the Shallow Tray units due to its operation without a noisy blower. Additional research into the availability and operations of low-profile air strippers should be performed before a specific configurations is selected.



Table 1
Rowe Spring Sampling Results

Summary of Detected Organics (All values are in micrograms per liter)

SAMPLE #	DATE	Chloroform	1,1-Dichloroethene	1,2-Dichloroethenes	1,1,1-Trichloroethane	Trichloroethene
1	4-Oct-93	6.1	0.48	42	10	27
2	17-Nov-93	7.1	<0.50	53	9.9	30.4
3	3-Dec-93	1.8	<0.50	27	4.5	16
4	15-Dec-93	2.7	<0.50	27	4.4	14.2
5	29-Dec-93	1.6	<0.50	33	6.1	18.8
6	18-Jan-94	3.2	1.06	40	8.1	23.5
7	26-Jan-94	3.5	<0.50	32	6.6	19
8	25-Feb-94	1.0	<0.50	34	4.9	16
9	4-Mar-94	1.1	<0.50	37	6.2	19.6
10	17-Mar-94	<0.50	<0.50	7.7	0.85	4.47
11	1-Apr-94	<0.50	<0.50	5.7	0.93	3.97
12	15-Apr-94	<0.50	<0.50	14	2.7	8.29

The following compounds were also analyzed but were not detected in any of the samples collected.
The lower detection limit for each analyte measured in micrograms per liter is presented in parentheses.

Acetone (13.0)	trans-1,3-Dichloropropene (0.70)
Benzene (0.50)	Ethylbenzene (0.50)
Bromodichloromethane (0.59)	Methyl n-butyl ketone (3.6)
Bromoform (2.6)	Dichloromethane (2.3)
Bromomethane (5.8)	Methyl isobutyl ketone (3.0)
Methyl ethyl ketone (6.4)	Styrene (0.50)
Carbon disulfide (0.50)	Tetrachloroethane (0.51)
Carbon tetrachloride (0.58)	Tetrachloroethene (1.6)
Chlorobenzene (0.50)	Toluene (0.50)
Chloroethane (1.9)	1,1,2-Trichloroethane (1.2)
2-Chloroethyl vinyl ether (0.71)	Trichlorofluoromethane (1.4)
Chloromethane (3.2)	Vinyl acetate (8.3)
Dibromochloromethane (0.67)	Vinyl chloride (2.6)
1,1-Dichloroethane (0.68)	Xylenes (0.84)
1,2-Dichloroethane (0.50)	Acrolein (100)
1,2-Dichloropropane (0.50)	Acrylonitrile (100)
cis-1,3-Dichloropropene (0.58)	

Figure 1
Total VOC Concentration vs. Springflow at Rowe Spring

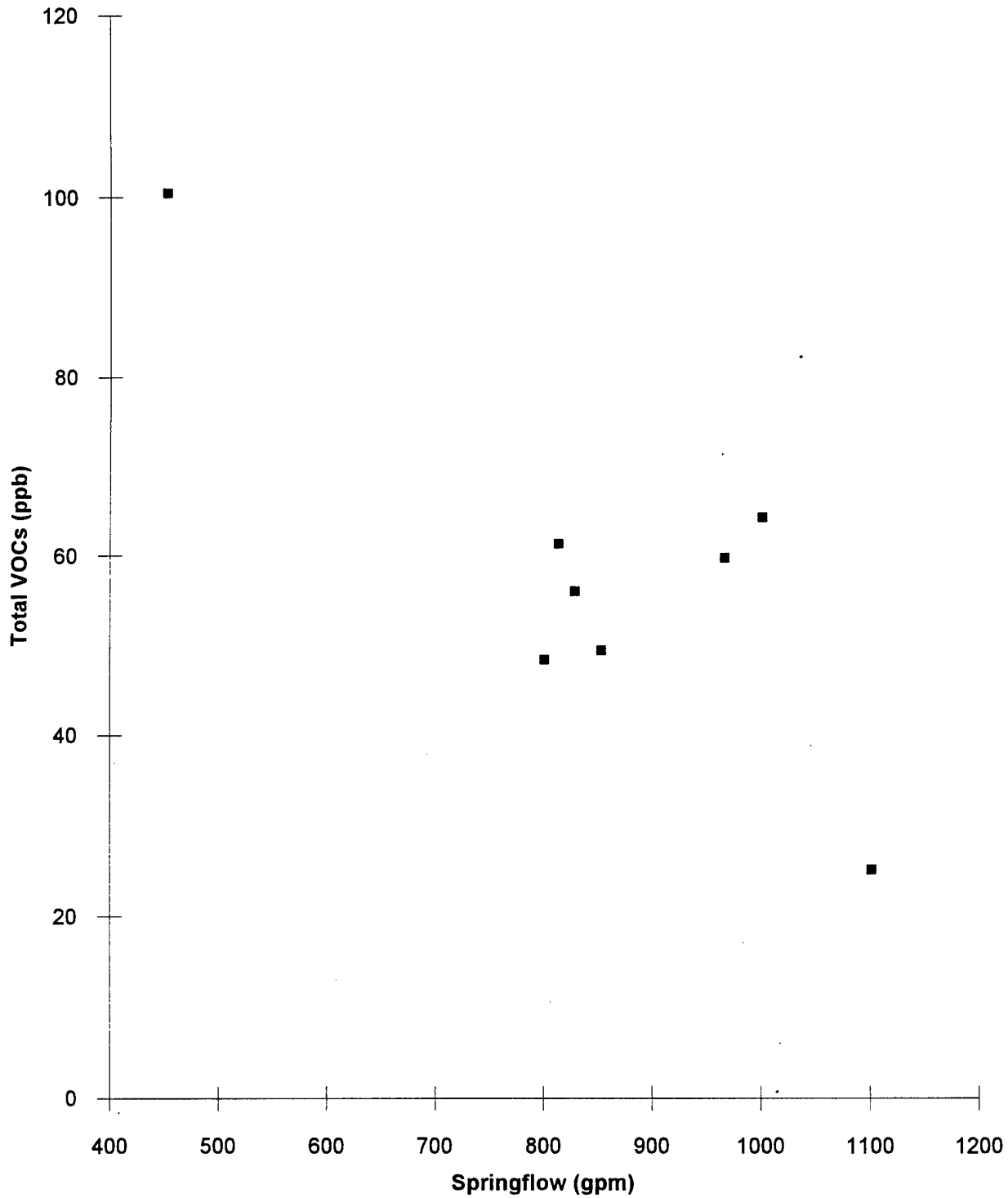




Table 2

Cost Estimate for Ultraviolet Oxidation

Capital Costs (3000 gpm): <ul style="list-style-type: none">• Solarchem Environmental Systems, Inc.	\$12,000,000
Yearly O&M (based on 700 gpm) <ul style="list-style-type: none">• Power (1 MW @ \$0.06/kWhr)• Lamp replacements (every 3000 hrs.)	\$950,000
Total Present Worth (based on 100 years at 5% interest with capital equipment replacement every 20 years)	\$38,000,000

Table 3

Cost Estimate for Photocatalytic Oxidation

Capital Costs (3000 gpm): <ul style="list-style-type: none"> • Power Distribution Cabinet • TiO₂ Reactor Subsystem • TiO₂ Separation System 	\$5,340,000
Yearly O&M (based on 700 gpm) <ul style="list-style-type: none"> • Power (200 kW @ \$0.06/kWhr) • Lamp replacements (every 8000 hrs.) 	\$195,000
Total Present Worth (based on 100 years at 5% interest with capital equipment replacement every 20 years)	\$12,400,000

Table 4

**Cost Estimate for Low-Profile Air Stripping
(Shallow Tray Air Strippers)**

Capital Costs (3000 gpm): <ul style="list-style-type: none"> • Four Shallow Tray Model 81241 Units • Calgon Vapor Phase Carbon Unit (10 ft. dia.) • Initial Carbon Supply (\$2.30/lb. includes regeneration and transportation costs) 	\$450,000 \$36,000 \$18,000 <hr/> \$504,000 Total
O&M (based on 700 gpm) <ul style="list-style-type: none"> • Power (65 kW @ \$0.06/kWhr) • Carbon replacements (8000 lbs.) 	\$34,000 per year \$18,000 per 5 yrs.
Total Present Worth (based on 100 years at 5% interest with capital equipment replacement every 20 years)	\$1,500,000

Table 5

**Cost Estimate for Low-Profile Air Stripping
(Hazleton Environmental Maxi-Strip)**

Capital Costs (3000 gpm): <ul style="list-style-type: none"> • Six parallel trains of 5-Module Model 625 units • Calgon Vapor Phase Carbon Unit (10 ft. dia.) • Initial Carbon Supply (\$2.30/lb. includes regeneration and transportation costs) 	\$733,000 \$36,000 \$18,000 <hr/> \$787,000 Total
O&M (based on 700 gpm) <ul style="list-style-type: none"> • Power (113 kW @ \$0.06/kWhr) • Carbon replacements (8000 lbs.) 	\$59,000 per year \$18,000 per 5 yrs.
Total Present Worth (based on 100 years at 5% interest with capital equipment replacement every 20 years)	\$2,500,000

Table 6

Comparison of Alternatives

Alternative	Ultraviolet Oxidation	Photocatalytic Oxidation	Low-Profile Air Stripping	Low-Profile Air Stripping
Alternative Example	Solarchem	Purifics	Shallow Tray Air Strippers	Hazleton Environmental Maxi-Strip
Potential Permits	NPDES	NPDES	NPDES/Air	NPDES/Air
Power/Utility Requirements	1000 kW @ 480 VAC, 3-phase	200 kW @ 440 VAC, 3-phase	65 kW @ 230 VAC, 3-phase	113 kW @ 230/460 VAC, 3-phase
PLC Control Availability	Yes	Yes	Yes	Yes
Waste Generation	None	None	8000 lbs. of spent carbon every 5 yrs.	8000 lbs. of spent carbon every 5 yrs.
Onsite Chemical Storage	hydrogen peroxide, acid, and base	None	None	None
Noise Levels	Quiet	Quiet	Blower Noise	Quiet
Required Maintenance *	3 lamp changes per year, plus refills of peroxide, acid, and base	yearly lamp replacement	Carbon changeout every 5 years	Carbon changeout every 5 years
Total Present Worth **	\$38,000,000	\$12,400,000	\$1,500,000	\$2,500,000

* Required maintenance in addition to the routine maintenance (i.e. replacement of pumps, valves, PLCs, etc.) that all alternatives will encounter.

** Present worth based on 100 years at 5% interest with capital equipment replacement every 20 years.

APPENDIX B
MAJOR EQUIPMENT LIST



MAJOR EQUIPMENT LIST

- 1) **Withdrawal Pump**
 - Quantity: 2
 - Type: Vertical Turbine
 - Capacity: 750 gpm
- 2) **Influent Equalization Tank**
 - Capacity: 35,000
 - Construction: Concrete
 - Dimensions: 36 x 20 x 8
- 3) **Low Profile Air Stripping System**
 - Function: Removes volatile organic compounds from aqueous phase media
 - Model: Hazleton Environmental Model 625
 - Quantity: 3 parallel trains of 5 units
 - Capacity: 5-500 gpm per train
 - Accessories: Control Package
Offgas Recirculation Package
Recirculation Pumps & Piping
- 4) **Influent Pumps**
 - Quantity: 4 (3 main, 1 spare)
 - Type: Centrifugal
 - Capacity: 500 gpm
- 5) **Offgas Blower**
 - Quantity: 1
 - Type: Positive Displacement
 - Capacity: 3,000 scfm
- 6) **Vapor Phase Carbon**
 - Function: Removes volatile organic compounds vapor phase media
 - Quantity: 2
 - Capacity: 3,000 scfm at 4 psi



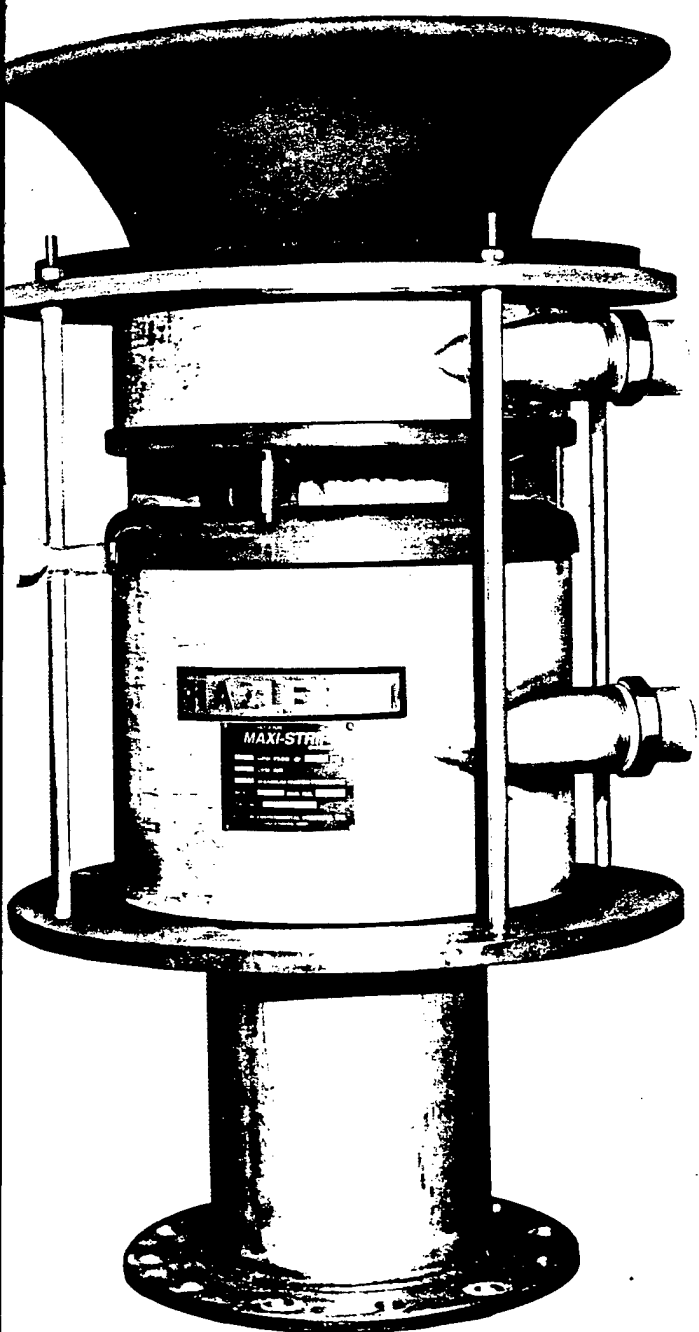
APPENDIX C

HAZLETON ENVIRONMENTAL VENDOR INFORMATION

(Inclusion of this information does not imply endorsement.)

Air Stripping

without
packing
or
blowers

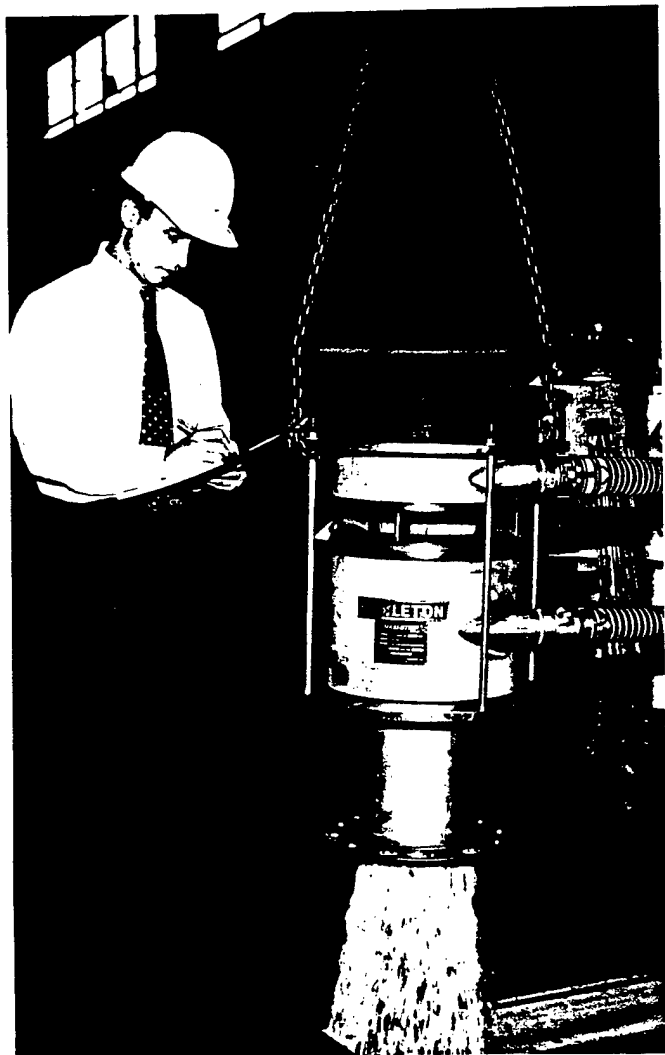


Environmental

Maxi-Strip[®]
Systems

Hazleton Maxi-Strip® Systems

The removal of VOCs from dirty water has never been so easy



MAXI-STRIP® on the test floor

In developing the patented Maxi-Strip® System, Hazleton Environmental has overcome the difficulties conventional air strippers experience with water containing high concentrations of suspended and dissolved solids.

HOW IT WORKS

Maxi-Strip®

The Maxi-Strip® is the heart of the system which is engineered to take advantage of Hazleton's design advances in fluid dynamics.

The Maxi-Strip® uses highly turbulent jets of water to shear and accelerate fluid films in an open bore. The microturbulence achieved in the bore creates the large surface area which is normally produced by packing or trays in a tower type air stripper. The same films and jets also aspirate air, eliminating the need for blowers.

The Maxi-Strip® was designed to cope with the iron and biological concentrations associated with ground water remediation and highly loaded waste streams. Early stage development of this technology was to oxidize and precipitate high concentrations of metals from mine drainage and metallurgical industries. Commercial units are currently in use to precipitate iron from acid mine drainage, coal pile runoff and maintenance wastes at several coal mines and power plants.

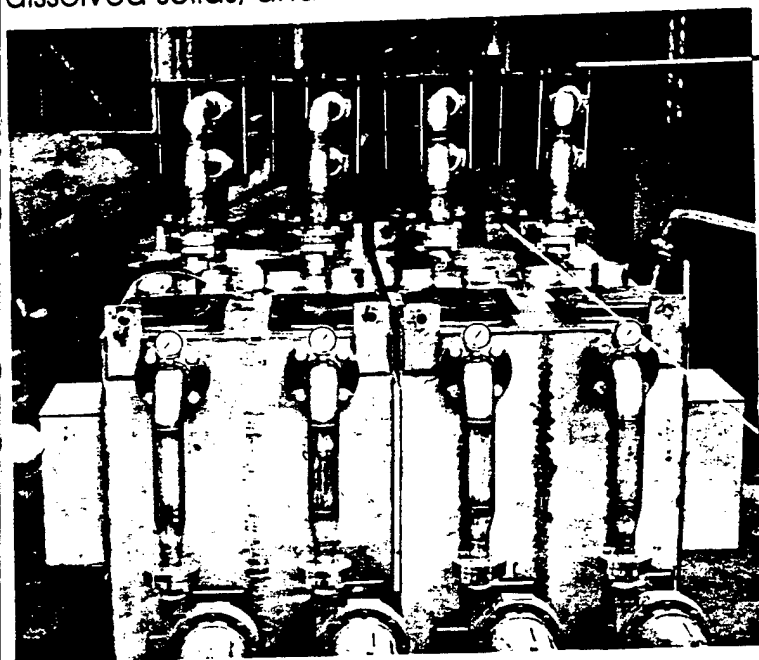
Maxi-Tank™

The Maxi-Tank™ acts as a sump to collect the water discharged from the Maxi-Strip®, allowing the off gas to separate and be collected.

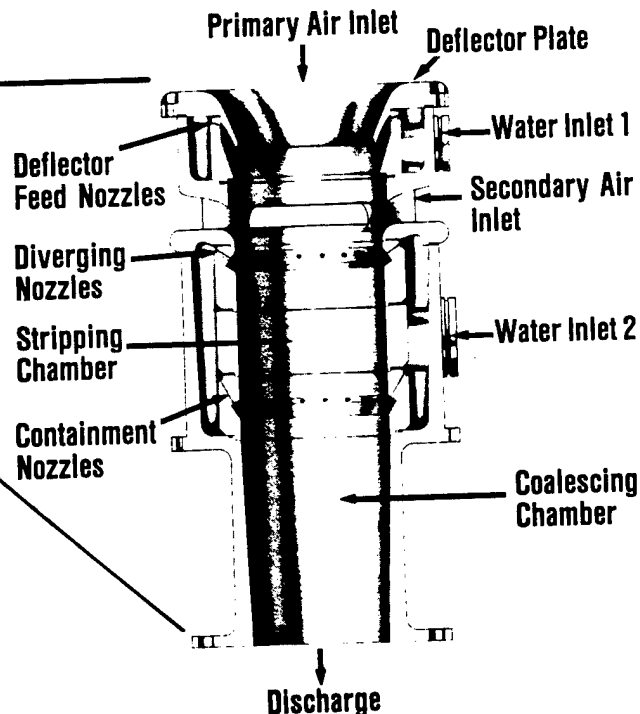
Engineered with a "gravity in gravity out" flow concept, the simple two baffle design limits dilution and allows infinite flow turndown. Infinite turndown means the system will strip along a defined curve from the hydraulic limit of the tank down to 1 gpm without flooding or channeling. Zero flow operation can go on for several hours, making batch operation possible.

The Hazleton Maxi-Strip® System Advantage

The Hazleton Maxi-Strip® System eliminates the need for pretreatment and the costs associated with stripping VOC contaminated water that contains high concentrations of iron, suspended/dissolved solids, and bio slimes.



Four Module System



APPLICATIONS

- Ground Water Remediation
- Storm Water Run Off
- Storage Tank Bottom Water
- Pump Test Water Decontamination
- Short Term Clean-up

OPTIONS

- Off gas treatment available to meet air emission standards.
- Pilot units available.

By installing a Maxi-Strip® system to remove VOC contaminants, you will:

- Reduce operation and maintenance costs because there are **no packing materials** to plug.
- Eliminate "tuning" or balancing blower air with waterflows because there are **no blowers**.
- Earn the lowest cost of ownership, because the only moving parts are **centrifugal pumps** that are simple to maintain and require no special equipment or training.

HAZLETON ENVIRONMENTAL

125 Butler Drive
Hazleton, Pennsylvania 18201
Phone 717-454-7515 • FAX 717-454-7520



Hazleton Maxi-Strip® System

Mobile VOC Remediation

FEATURES

- Hydraulic Jet Aspirating Stripper
- Self Cleaning/Auto Decontamination
- Self Contained Modular Design
- Quick Connect System Design
- Trailers Easily
- Computer Modeling of Contaminants
- Prewired - piped - factory tested
- Complete Technical & Field Support Available



Off-gas Carbon Canisters Removed For Clarity

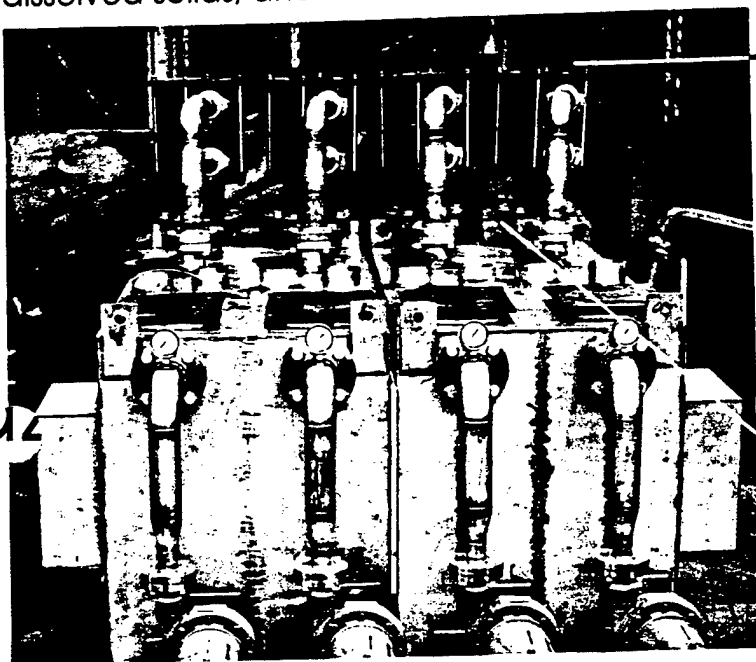
BENEFITS

- 99.9% Removal rates.
- 1 - 100 gpm flows.
- Minimal start-up / take down time required.
- Provides worry-free installation and operation.
- Eliminates pretreatment; no packing or trays to foul from high iron or suspended/dissolved solids.

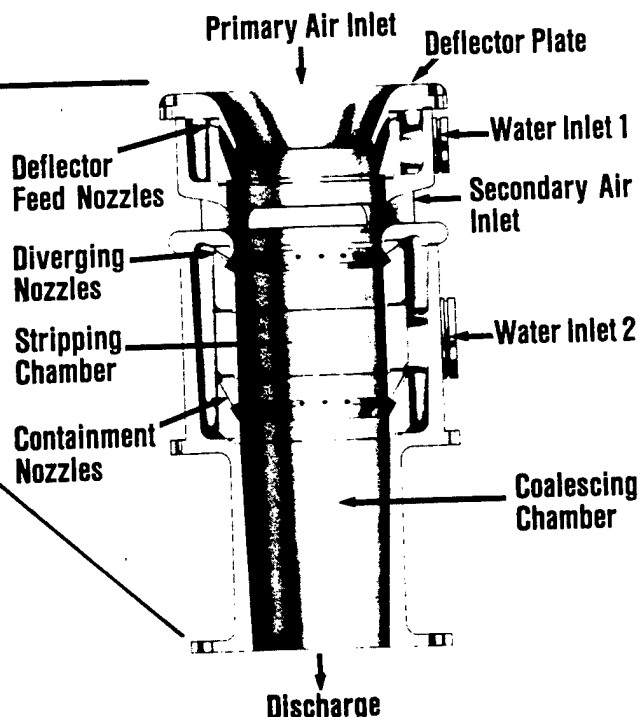
Field tested computer simulation is used to design the optimal system for your application.

The Hazleton Maxi-Strip® System Advantage

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Four Module System



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Hazleton Maxi-Strip® System

Mobile VOC Remediation

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Off-gas Carbon Canisters Removed For Clarity

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- Provides worry-free installation and operation.
- Eliminates pretreatment; no packing trays to foul from high iron or suspended/dissolved solids.

Field tested computer simulation is used to design the optimal system for your application.

MAXI-STRIP® SYSTEM

The Maxi-Strip® System is an extremely flexible modular design. The number of modules is determined by the flow through the system and the effluent quality required.

Each module is complete with; stripper, tank and a small pump. Flow into and out of a module is by gravity so multiple modules are simply bolted together.

The flexibility is apparent when conditions change. For a significantly different influent concentration or flow, just add a module or turn one off as required. Flow changes are only limited by the hydraulic capacity of the tanks.

MODULE CAPACITY

Model Number	gpm min	gpm max	Air Flow* acfm
100	1	100	227
350	1	350	795
500	1	500	1,136

*Indicates maximum airflow. Within a system the airflow can be reduced by recirculation.

MODULE SIZE

Model Number	Width Inches	Length Inches	Height Inches
100	14	100	60
350	45	150	100
500	52	160	150

Dimensions include stripper and pump.

COMPUTER MODELING is used to size an application and predict the performance of an operating system.

ADVANTAGES

DIFFICULT TO PLUG the Maxi-Strip® System has no packing to foul when water contains iron, sediment or biological contaminants.

MAINTENANCE inspections are conducted on site, by non-technical personnel, who can remove, repair or reinstall unit components in hours without special tools or equipment.

LOW PROFILE at nearly 1/4 the height of a packed tower, the Maxi-strip System will not stick out in residential areas and can usually fit into existing facilities.

LOW COST INSTALLATION minimal site preparation, equipment and time required. Systems can be placed on any level surface.

NO BLOWER NOISE allows operation in sensitive areas.

NO TUNING a constant flux ratio and infinite turndown eliminate tuning, one switch...to turn the unit on or off.

IMPOSSIBLE TO FLOOD OR CHANNEL

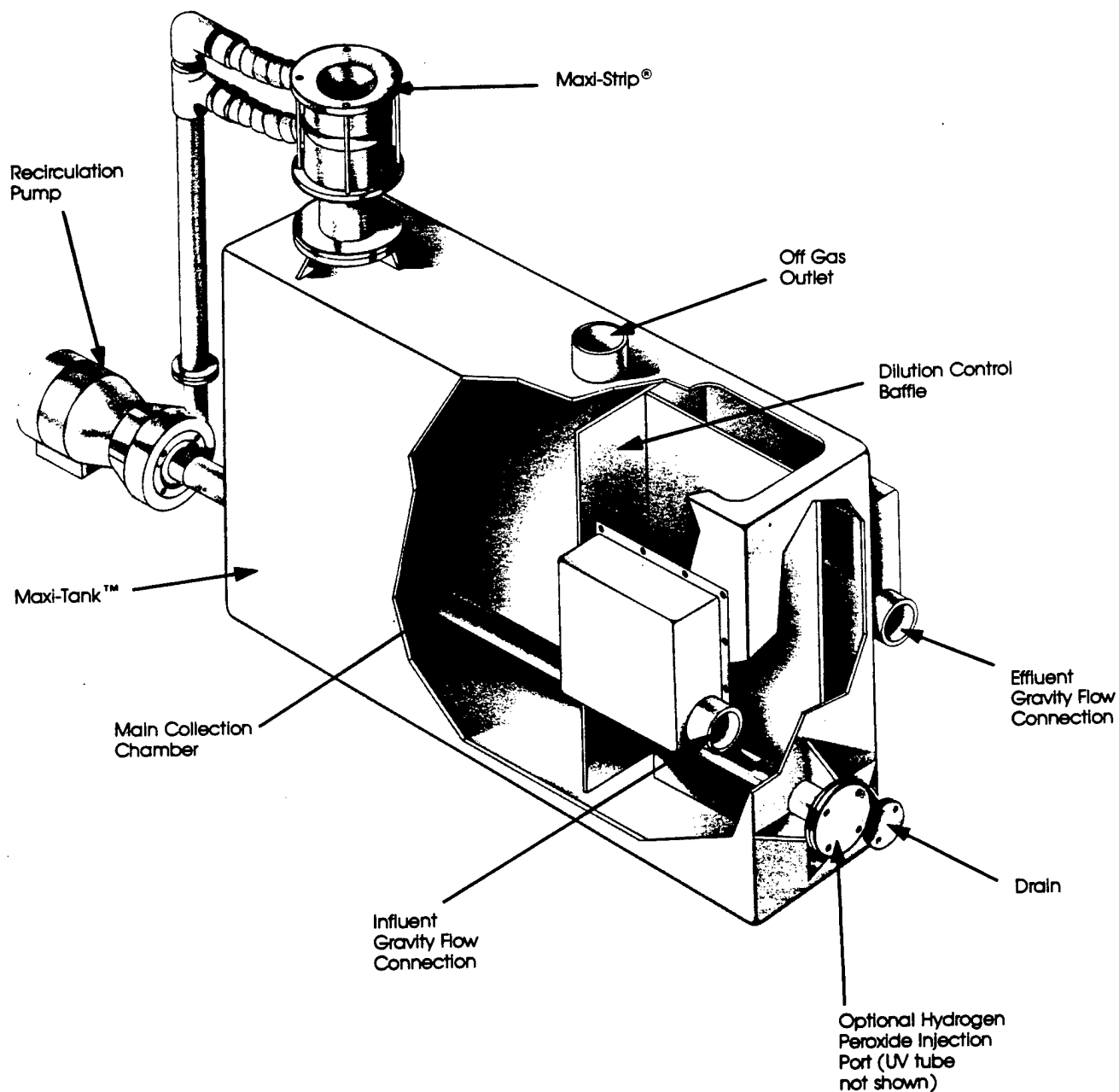
TRAILER MOUNTING AVAILABLE the system can be transported and operated in an enclosed trailer.

COMPANY BACKGROUND

Hazleton Environmental was formed to serve the needs of the growing water treatment industry. Our products and processes are patented and represent many years of development in the treatment of water for the coal, steel, and power industries. Our staff can provide full engineering design, construction and start-up support for our systems. We can provide the best system to fulfill your requirements.

HAZLETON Maxi-Strip® System

Single Module System



Represented by:



HAZLETON ENVIRONMENTAL

125 Butler Drive

Hazleton, PA 18201

Phone 717-454-7515 FAX 717-454-7520



APPENDIX D

GEOTECHNICAL INVESTIGATION REPORT

Demonstration Off-Post Groundwater Treatment Plant (Rowe Spring): Geotechnical Investigation

Contract No. DACA31-91-R-0009
Task Order No. 03

May 1996

Prepared for:
U.S. Army Environmental Center (USAEC)
SFIM-AEC-IRA
Aberdeen Proving Ground, MD 21010-5401

Prepared by:
Roy F. Weston, Inc.
1 Weston Way
West Chester, Pennsylvania 19380-1499
96P-1815

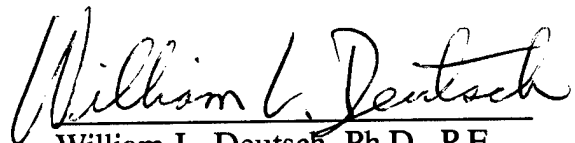


**GEOTECHNICAL INVESTIGATION
FOR
OFF-POST GROUNDWATER TREATMENT PLANT**

Prepared for:

U.S. Army Environmental Center
SFIM-AEC-IRA
Aberdeen Proving Ground, MD 21010-5401

24 May 1996

A handwritten signature in black ink, reading "William L. Deutsch". The signature is written in a cursive style with a horizontal line underneath the name.

William L. Deutsch, Ph.D., P.E.
Senior Technical Director
Geotechnical Engineering

Prepared By:

Roy F. Weston, Inc.
One Weston Way
West Chester, Pennsylvania 19380-1499

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1.0 INTRODUCTION

The geotechnical investigation reported herein was performed for the U.S. Army Environmental Center (USAEC) in conjunction with the proposed design and construction of an off-post groundwater treatment plant near the Letterkenny Army Depot (LEAD) site in Chambersburg, Pennsylvania. The purpose of this investigation was to explore the subsurface conditions at the site of the proposed construction in order to formulate recommendations for the design and construction of a foundation system for the proposed facility, as well as related site earthworks. The scope of work included completion of a subsurface exploration program by test borings, laboratory testing of recovered soil samples, engineering analysis of the available geotechnical data, development of recommendations, and preparation of this report.

2.0 PRODUCT DESCRIPTION

The proposed groundwater treatment plant structure will be located on farmland adjacent to Rowe Run Road approximately $1\frac{1}{4}$ miles northeast of the Letterkenny Army Depot main gate in Chambersburg, Pennsylvania. The structural footprint of the proposed structure will be approximately 24 feet by 37 feet (i.e., approximately 900 ft²). It is understood that the finished floor elevation of the structure and the top of concrete slab elevation will approximately match the existing site grades. It is further understood that no below grade structures or depressed areas within the structural footprint are proposed.

3.0 SITE CONDITIONS

The site of the proposed construction presently consists of farmland which is in active production at the present time. The existing ground surface elevation within the footprint of the proposed construction ranges from approximately 646 feet to 644 feet, generally sloping from south to north. The site lies directly behind the current residence of Mr. Gerald Anthony. Existing structures immediately adjacent to the site include a double wide trailer home, wooden deck and storage shed as shown on Figure 1, Site and Boring Location Plan.

4.0 SUBSURFACE CONDITIONS

Subsurface conditions in the vicinity of the proposed construction were investigated by installing a total of two (2) test borings located as shown on Figure 1, Site and Boring Location Plan. As noted in this Figure, the borings had to be offset from the proposed structural footprint because of the presence of overhead electric lines and other site access constraints. The individual boring logs are presented in Appendix A. The subsurface stratigraphy at the boring locations, the Standard Penetration Resistance (i.e., "N") values, and the classification of the various soil and bedrock materials encountered during the drilling work are presented on the logs. The stratigraphic interface depths and elevations are also presented on the logs as well as groundwater information.

The test borings were completed by Testwell-Craig Test Boring Company of Mays Landing, New Jersey, under the supervision of a WESTON Geotechnical Engineer who directed the boring work, classified the soils encountered in accordance with the Unified Soil Classification System, and prepared continuous boring logs. The boring locations were established by taping from the back corners of the existing Anthony home. Approximate ground surface elevations were determined from the topographic maps of this site prepared as part of this project. The test borings were drilled on January 4 and 5, 1996.

The test borings were completed using a truck-mounted drill rig and were conducted by advancing hollow stem augers. Samples of the subsoils were recovered from the borings for identification and classification purposes by means of a two-inch O.D. split barrel sampler driven 18 inches by a 140-pound hammer freely falling 30 inches (the Standard Penetration Resistance Test, ASTM D-1586). The number of hammer blows required to drive the sampler during the interval from 6 to 18 inches, or fraction thereof, is reported on the test boring logs as the "N value".

The site of the proposed construction lies within a limestone bedrock environment. Overburden materials consist of fine grained residual soils derived from weathering of the

parent bedrock and underlie 6 to 12 inches of topsoil. The encountered subsurface materials are discussed in greater detail in the following paragraphs.

The residual overburden soils were geotechnically logged as brown sandy silty clay of medium plasticity which grades with depth to a lower plasticity brown sandy clayey silt. These materials classify as CL (sandy silty clay) and ML (sandy clayey silt) according to the Unified Soil Classification System (USCS). The N values encountered within the sandy silty clay soils range from 14 to 31 blows per foot. Within the underlying sandy clayey silt soils, the N values range from 25 blows per foot to 79 blows per 11 inches of penetration.

Auger refusal on intact limestone bedrock was encountered at depths of 13.0 and 17.0 feet in the two borings. A total of 20 feet and 15 feet of bedrock was cored in Borings B-1 and B-2, respectively. The B-1 core run indicates that significant weathering of the limestone bedrock has occurred which has created fine-grained soil inclusion zones within the rock which was washed away quickly with the core water. This in turn caused the core barrel to drop more rapidly through these eroded soil zones within the rock as documented on the boring logs. The B-2 core run indicates the presence of fresh, intact, solid rock at this location. The measured "Percent Recovery" and "Rock Quality Designation" (RQD) values for the various 5 foot core runs are also presented on the logs.

Groundwater was encountered during the drilling work at depths of 7.5 and 7.0 feet in Borings B-1 and B-2, respectively. It is noted that groundwater levels are subject to daily and seasonal variations dependent on climatic conditions.

5.0 LABORATORY TESTING PROGRAM

A limited number of physical property tests were completed in our Geotechnical Laboratory in Lionville, Pennsylvania on selected, representative split-spoon soil samples. These test results were used to define stratigraphical continuity, to enable proper classification of these materials according to the Unified Soil Classification System (USCS), and to serve as indices to soil behavior. These tests consisted of Grain Size Distribution by Sieve and Hydrometer

Analysis (ASTM D421/422), Atterberg Limits (ASTM D4318), Natural Moisture Content (ASTM D2216), and Moisture, Ash and Organic Content (ASTM D 2974). The results of these tests are presented in Appendix B.

6.0 FOUNDATION CONDITIONS

The presence of dense, stable overburden soils in combination with the light structural loadings warrants a shallow foundation system for support of the structure. This foundation system would normally consist of concrete spread/wall footings for support of the building superstructure, and concrete mat foundations for support of equipment, tanks, etc. within the structure. However, because of the presence of highly weathered, compressible and possibly voided limestone bedrock directly beneath the structure as evidenced by the rock coring results, it is deemed appropriate to use a shallow foundation support system which can be structurally designed to span over areas of localized differential settlement and/or overburden soils which have collapsed into underlying void spaces within the rock. This type of shallow foundation system typically consists of a large single concrete mat foundation which extends over the entire building footprint, and is structurally designed with adequate concrete thickness and steel reinforcement to span over a loss of support area as specified in the design. Based on the results of our subsurface investigation program, this loss of support area should be assumed to be of circular geometry with a diameter of 5 feet. Detailed recommendations pertinent to this selected foundation system, as well as related earthworks design and construction recommendations, are presented in the remaining sections of this report.

7.0 RECOMMENDATIONS

7.1 Site and Subgrade Preparation

Before construction commences, all topsoil, root mass, trees and other vegetation and rootmass should be removed from within the limits of the proposed structural footprint. These materials may be reused in other areas of the site adjacent to the structure in which grading fill is required consistent with the developed final grading plan for the construction.

7.2 Shallow Foundations

The proposed structure should be founded on a concrete mat foundation bearing on the insitu residual soils or on compacted undercut backfill as discussed subsequently. The mat foundation should be proportioned for combined dead and live loadings so as not to exceed an allowable bearing pressure of 1,500 psf. The mat foundation should include a perimeter frost wall which bears at least 2.5 feet below immediately adjacent finished exterior grades for protection of the mat against frost heave. The mat foundation should be structurally designed to span over a 5 foot diameter loss of support at any location within the mat footprint.

Following excavation of the surficial soils to the foundation bearing grades, the entire subgrade surface should be both handprobed by an Inspecting Engineer and proofrolled on grade until dense and stable using a heavy-duty, smooth drum roller. Should soft, weak or otherwise unstable areas be detected by the handprobing and/or proofrolling, these materials should be undercut until dense, stable insitu materials are encountered. The undercut surface should subsequently be compacted on-grade until dense and stable, followed by backfill of the undercut zone to the design subgrade elevations using compacted fill which is placed and compacted using controlled, thin-lift construction techniques as discussed in a subsequent section of this report.

Before concrete placement, a 4-inch thick granular base course should be placed over the entire subgrade surface. The base course should consist of a washed gravel or washed crushed stone that is graded between a maximum particle size of 1½ inches and the No. 4 sieve, with not more than 10 percent finer than the No. 4 sieve, such as AASHTO Coarse Aggregate No. 57.

7.3 Sinkhole Mitigation

As discussed previously, the site of the proposed construction is underlain by calcium carbonate bedrock (i.e., limestone). This material is water soluble and can dissolve in groundwater. If sufficiently developed, this dissolution process can result in the formation of voids within the rock mass. If these voids become sufficiently large in size, the overburden soils can collapse into the void space. The surface manifestation of this process is a sinkhole.

The development of sinkholes can seriously impact the performance of shallow foundations founded in overburden soils above calcium bedrock deposits. In order to reduce the potential for sinkhole development, various design and construction measures can be implemented as discussed below. The common theme of the various measures is that surface water should be prevented from infiltrating into the subsoils, particularly at concentrated locations near the proposed structure.

Design Measures

1. Water-bearing utilities should not run adjacent to foundations.
2. Roof drains should be tied directly into the storm drain system which in turn should discharge to Rowe Run creek. Collected rainwater should not be allowed to discharge onto the ground.
3. Storm drains should be made as watertight as practical by using reinforced concrete pipes with O-ring joint gaskets, etc.
4. Dense-graded, impervious pavement should be used. Junctions with curbs and catch basins should be sealed with hot liquid asphalt.
5. Minimize the depth of cut in building and parking areas to avoid removal of natural impervious capping material.
6. Landscaped areas should be graded to promote rapid runoff away from the structure. Landscaped areas located immediately adjacent to structures should be minimized.
7. Unpaved swales should be avoided.

Construction Measures

1. During site grading, avoid leaving depressions that can fill with rainwater. After a storm, pump out any such puddles that occur. Grade to promote rapid drainage away from the construction.
2. Do not excavate outside foundations that cannot be cast the same day, unless it is certain that precipitation will not occur overnight.
3. Backfill foundations as soon as possible to avoid water from ponding around foundations. Quickly pump out any ponding that occurs.
4. Construct storm drains carefully to avoid any open joints. Carefully seal pipe lifting holes with cement. Reject cracked or broken pipe sections. Carefully seal joints at catch basins and manholes.
5. Any sinkholes that occur or that are uncovered by excavation should immediately be addressed and properly remediated.

7.4 Compacted Fill

Compacted fill may be required as undercut backfill (Class A fill) or for general site grading purposes (Class B fill). All compacted fill should be placed and compacted in accordance with the following recommendations:

7.4.1 Fill Materials

Class A fill should consist of imported, non-plastic, select granular material having a maximum particle size of 2-inches with not more than 10 percent finer than the No. 200 sieve, such as AASHTO Coarse Aggregate No. 2A or PennDOT 2RC. Class B fill should consist of the clayey or silty soils which may be excavated within required undercut zones beneath the structural footprint as part of the proposed construction. (Class A fill may also be used for site grading purposes if undercutting is not required beneath the structural footprint.) It must be noted that the Class B fill soils will be extremely moisture sensitive and may be difficult to compact if the moisture content of the soil mass is not at, or very close, to its optimum moisture content. The Class B materials are most effectively placed and compacted in hot and dry weather conditions.

7.4.2 Fill Compaction

All compacted fill should be placed in approximately horizontal lifts not exceeding a loose thickness of 8-inches. Compacted fill placed as undercut backfill for the support of the mat foundation and as site grading fill which will support structural loadings including sidewalks and roadways should consist of Class A material which is compacted to at least 95 percent of the maximum dry density as determined by the Modified Proctor Compaction Test (ASTM D-1557). Compacted fill which is placed for general site grading requirements (i.e., landscaping fill) and which will not support any structural elements should consist of Class B material which is compacted to at least 90 percent of the maximum modified dry density.

7.5 Construction Inspection

It is recommended that all foundation construction and related earthworks activities be inspected on a full-time basis by a qualified Geotechnical Engineer or Technician who is thoroughly familiar with the site subsurface conditions, general shallow foundations and earthworks construction techniques, and the project design requirements. The Geotechnical Engineer/Technician should observe and document the construction activities and complete appropriate field tests, as necessary, to determine that the construction is performed in accordance with the plans, specifications, and good construction practice.

8.0 LIMITATIONS

All conclusions and recommendations presented in this report are based on the assumption that the subsurface conditions do not deviate appreciably from those disclosed by the test borings and are subject to confirmation and revisions based upon our review of the final plans and specifications covering pertinent details of the proposed construction. These conclusions and recommendations must also be based on the premise of competent field engineering and inspection during construction.

PLOTTED 03/14/96 10:55 am
 PLT. SC. 1=1
 FILE NO. MISC/LOCPLAN

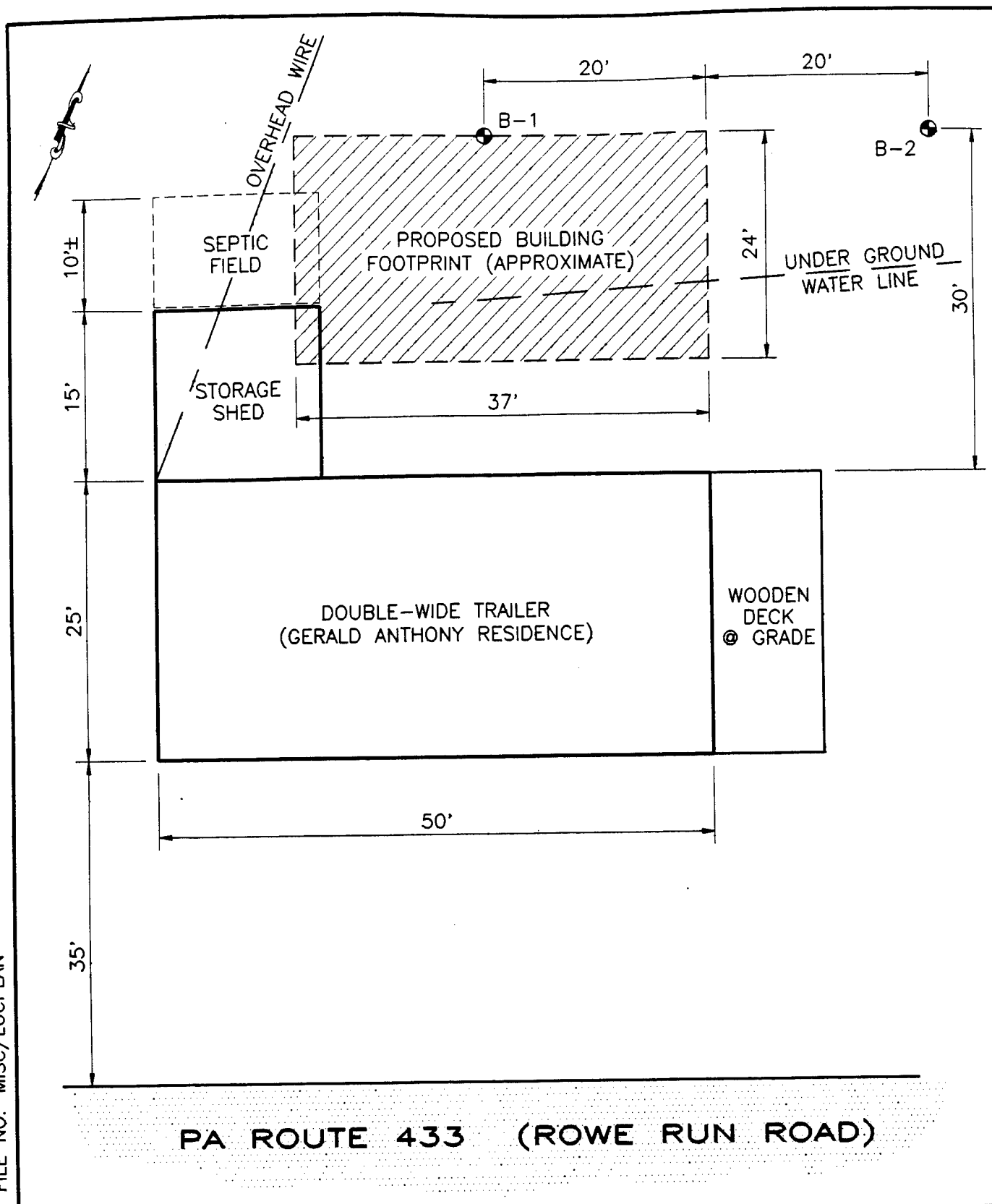


FIGURE 1
SITE AND BORING
LOCATION PLAN
(NTS)



DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
CHECKED	DATE	APPROVED	DATE	DWG. NO.

APPENDIX A

WESTON					SOIL BORING LOG			PAGE 1 OF 2		
Job Name		USAEC- Letterkenny		Boring No.		B-1		Groundwater Level		
Job No.		02218-012-003		Surface Elev.		645'		Date	Depth	
Date Drilled		Jan. 4, 1996		Boring Method		Hollow Stem Auger		1/5/96	7.5 feet bgs	
Drilling Co.		Craig Test Boring Co.		Completion Depth		37.0 ft bgs				
Drill Foreman		Bob Kimley		Location		G. Anthony property				
Logged By		Brian Miller				on PA route 433.				
Depth (feet)	Sample No.	Sample Type*	Sample Blow Counts* (per 6 in.)	N Value*	Visual Description		Stratum Elev.	% Rec	% RQD	Laboratory Tests
	S1	SS	2-2-3-4	5	6" Topsoil			25		
	S2	SS	4-7-9-9	16	Brown sandy, silty clay (CL)			100		SH
5	S3	SS	4-6-9-9	15				100		AL
	S4	SS	11-21-10-10	31				100		MC, OC
	S5	SS	6-8-9-11	17				100		SH, MC
10										
15	S6	SS	6-29-50/5"	79/11"	Brown sandy clayey silt (ML)			40		
17	Run 1	RC			Encountered top of rock at 17.0 feet bgs			67	63	
20					Gray limestone, hard, weathered, few fractures.					
22	Run 2	RC			Soil-like material 19 to 20 ft (Core barrel dropped rapidly)					
					Gray limestone, hard, weathered, frequent fractures.					
25					20 to 23 feet			12	12	
27	Run 3	RC			Weathered soil-like material. 23 to 29 feet (Core barrel dropped quickly but little water was lost. Water returned with suspended soil particles.)					
30					Recovered 4" of brown silt, some fine-medium sand at about 28.5 feet bgs.			60	20	
32					Gray limestone, hard, weathered, frequent fractures.					
					29 to 37 feet					
					Continued on next sheet					

Sample type: SS-Split Spoon
ST-Shelby Tube
RC-Rock Core
SC-Soil Core

Laboratory Tests: MC-Moisture Content
AL-Atterberg Limits
S-Sieve Analysis
SH-Sieve/Hydrometer Analysis
SG-Specific Gravity
OC - Organic Content

C-Consolidation
UU-Unconsolidated Undrained Triaxial
CU-Consolidated Undrained Triaxial
UCS-Unconfined Compressive Strength
K-Hydraulic Conductivity
BD - Bulk Density

*ASTM D-1586 Standard Penetration Test

PAGE 2 OF 2

Sample type:	SS-Split Spoon ST-Shelby Tube RC-Rock Core SC-Soil Core	Laboratory Tests:	MC-Moisture Content AL-Atterberg Limits S-Sieve Analysis SH-Sieve/Hydrometer Analysis SG-Specific Gravity OC - Organic Content	C-Consolidation UU-Unconsolidated Undrained Triaxial CU-Consolidated Undrained Triaxial UCS-Unconfined Compressive Strength K-Hydraulic Conductivity BD - Bulk Density
*ASTM D-1586 Standard Penetration Test				

WESTON					SOIL BORING LOG				PAGE 1 OF 1			
Job Name		USAEC- Letterkenny			Boring No.		B-2		Groundwater Level			
Job No.		02218-012-003			Surface Elev.		644.5'		Date		Depth	
Date Drilled		Jan. 5, 1996			Boring Method		Hollow Stem Auger		1/5/96		7.0 feet bgs	
Drilling Co.		Craig Test Boring Co.			Completion Depth		28.0 ft bgs					
Drill Foreman		Bob Kimley			Location		G. Anthony property					
Logged By		Brian Miller					on PA route 433.					
Depth (feet)	Sample No.	Sample Type*	Sample Blow Counts* (per 6 in.)	N Value*	Visual Description			Stratum Elev.	% Rec	% RQD	Laboratory Tests	
	S1	SS	1-2-4-4	6	12" Topsoil				75			
	S2	SS	4-6-8-14	14	Brown sandy silty clay (CL)				50		SH	
5	S3	SS	10-10-12-14	22					80		AL	
	S4	SS	11-12-12-14	24					100		MC,OC	
	S5	SS	11-12-13-13	25	Brown sandy clayey silt (ML)				100		SH, MC	
10												
13	Run 1	RC			Auger encountered top of rock at 13.0 feet bgs. Gray limestone, very hard, slightly weathered, few fractures.				67	50		
15												
18	Run 2	RC			Gray limestone, very hard, sound. (Very thin veins of quartz within the core.)				90	90		
20												
23	Run 3	RC			Gray limestone, very hard, sound. (Very thin veins of quartz within the core.)				100	100		
25												
28												
30					End of boring at 28 feet bgs. Run #4 not drilled due to damaged core barrel.							
									</			

Sample type: SS-Split Spoon
ST-Shelby Tube
RC-Rock Core
SC-Soil Core

Laboratory Tests: MC-Moisture Content
AL-Atterberg Limits
S-Sieve Analysis
SH-Sieve/Hydrometer Analysis
SG-Specific Gravity
OC - Organic Content

C-Consolidation
UU-Unconsolidated Undrained Triaxial
CU-Consolidated Undrained Triaxial
UCS-Unconfined Compressive Strength
K-Hydraulic Conductivity
BD - Bulk Density

*ASTM D-1586 Standard Penetration Test

APPENDIX B



Inter-Office Memorandum

TO: Brian Miller

cc: Bill Deutsch

FROM:

WB for
Russell Frye

DATE:

12 February 1996

PROJECT:

USAEC - LETTERKENNY

W.O. NO.:

02281-012-003-0030-00

SUBJECT:

Geotechnical Testing Results

ACTION:

Geotechnical testing results for the USAEC - LETTERKENNY project are attached. Eight (8) soil sample(s), job number 9601X003 were submitted to WESTON's Environmental Technology Laboratory (ETL) on 11 January 1996 for geotechnical testing.

The geotechnical tests requested are presented in the attached custody transfer/work request.

The geotechnical tests performed including reference method and test number are presented in Table 1.

If you require additional information or have any questions, please call me at (610) 701-6173.

Table 1
Geotechnical Tests Performed, Reference Methods and Test Numbers

Test Parameter	Method ¹	Test Numbers
Grain Size by Sieve and Hydrometer	D 421/422	4
Liquids and Plastic Limits	D 4318	2
Natural Moisture Content	D 2216	6
Moisture, Ash and Organic Content	D 2974	2



Custody Transfer Record/Lab Work Request

WESTON Analytics Use Only	
9601X003	

USAEC - LETTERKENNY

Client 02181-012-003-0030-00

Work Order

Date Rec'd. 06/11/96 Date Due 3654

RFW Contact BRIAN MILLER

Client Contact/Phone

WA Use Only Lab ID	Client ID/Description
001	B-1 S2
002	B-1 S3
003	B-1 S4
004	B-1 S5
005	B-2 S2
006	B-2 S3
007	B-2 S4
008	B-2 S5

Special Instructions:

Matrix: W - Water DS - Drum Solids X - Other
S - Soil O - Oil DL - Drum Liquids
SE - Sediment A - Air F - Fish
SO - Solid W1 - Wipe L - EP/CLP Leachate

Item/Reason Relinquished by Received by Date Time

001	Brian Miller	W. Brown	11 JAN 96	1400
002				
003				
004				
005				
006				
007				
008				

Refrigerator#	#Type Container	Volume	Preservative	ANALYSES REQUESTED	Grain Size (S+H)	Matrix	Date Collected	Relinquished by	Received by	Date	Time
						S	4 JAN 96				
						S					
						S					
						S					
						S	5 JAN 96				
						S					
						S					
						S					

Notes: 1 Received Broken/Leaking (Improperly Sealed) Y N
2 Ambient or Chilled NOTES:
3 Properly Preserved Y N
4 Received Within Holding Times Y N
5 Received Within Holding Times Y N

COC Tape Was:
1 Present on Outer Package Y N
2 Unbroken on Outer Package Y N
3 Present on Sample Y N
4 Unbroken on Sample Y N

COC Record Was:
1 Present Upon Receipt of Samples Y N
Discrepancies Between Sample Labels and COC Record? Y N

ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

MOISTURE ASH AND ORGANIC CONTENT

PROJECT	USAEC-LETTERKENNY	PROJECT ANALYST	JRA	OVEN MODEL	VWR
JOB NUMBER	9601X003	QA/QC ANALYST	RWF	OVEN TEMPERATURE, C	105
W. O. NUMBER	02281-012-003-0030-00	DATE RECEIVED	01/11/96	DATE COMPLETED	01/20/96

SAMPLE DATA

ETL Sample Number	001	002	003	004	005	006	007	008
Project Sample I. D.	B-1 S2	B-1 S3	B-1 S4	B-1 S5	B-2 S2	B-2 S3	B-2 S4	B-2 S5

MOISTURE CONTENT

Total Solids, %	83.3	81.3	82.2	80.0	87.2	84.4	83.0	83.6
Moisture Content, % wet	16.7	18.7	17.8	20.0	12.8	15.6	17.0	16.4
Moisture Content, % dry	20.0	23.0	21.7	25.0	14.7	18.4	20.4	19.6

ASH CONTENT

Ash Content, % wet	-	-	80.4	-	-	-	81.4	-
Ash Content, % dry	-	-	97.8	-	-	-	98.0	-

ORGANIC CONTENT

Organic Content, % wet	-	-	1.8	-	-	-	1.7	-
Organic Content, % dry	-	-	2.2	-	-	-	2.0	-

ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

ASTM D 4318 - LIQUID LIMIT, PLASTIC LIMIT, AND PLASTICITY INDEX OF SOILS			
PROJECT	USAEC	PROJECT ANALYST	JRA
JOB NUMBER	9601X003	QA/QC ANALYST	RWF
W. O. NUMBER	02281-012-003-0030-00	DATE COMPLETED	01/20/96

Project Sample I. D.	ETL Sample Number	INDEX PROPERTIES % moisture dry basis			USCS Class of Fine Fraction
		Liquid Limit	Plastic Limit	Plasticity Index	
B-1 S3	002	30.8	17.7	13.1	CL
B-2 S3	006	26.0	19.7	6.3	ML/CL

NOTES

ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	USAEC LETTERKENNY	PROJECT SAMPLE I.D.	B-1 S2	PROJECT ANALYST	JRA
JOB NUMBER	9601X003	ETL SAMPLE NUMBER	001	QA/QC ANALYST	RWF
W. O. NUMBER	02281-012-003-0030-00	DATE RECEIVED	01/11/96	DATE COMPLETED	01/18/95

PARTICLE SIZE DISTRIBUTION			
U. S. Standard Sieve Size	Diameter mm	% Finer	
3"	75.00	100.0	
1½"	37.50	100.0	
¾"	19.00	100.0	
3/8"	9.500	100.0	
#4	4.750	100.0	
#10	2.000	96.8	
#20	0.850	91.9	
#50	0.300	86.8	
#100	0.150	83.0	
#200	0.075	78.7	
HYDROMETER	0.0343	73.8	
	0.0261	65.8	
	0.0192	60.4	
	0.0143	53.8	
	0.0107	49.7	
	0.0079	43.1	
	0.0057	39.0	
	0.0041	37.7	
	0.0029	33.7	
	0.0021	29.7	
	0.0012	27.0	
	0.0009	27.0	

EFFECTIVE SIZES	
% Finer	Diameter mm
60	NA
30	NA
10	NA
Uniformity Coefficient	Gradation Coefficient
NA	NA

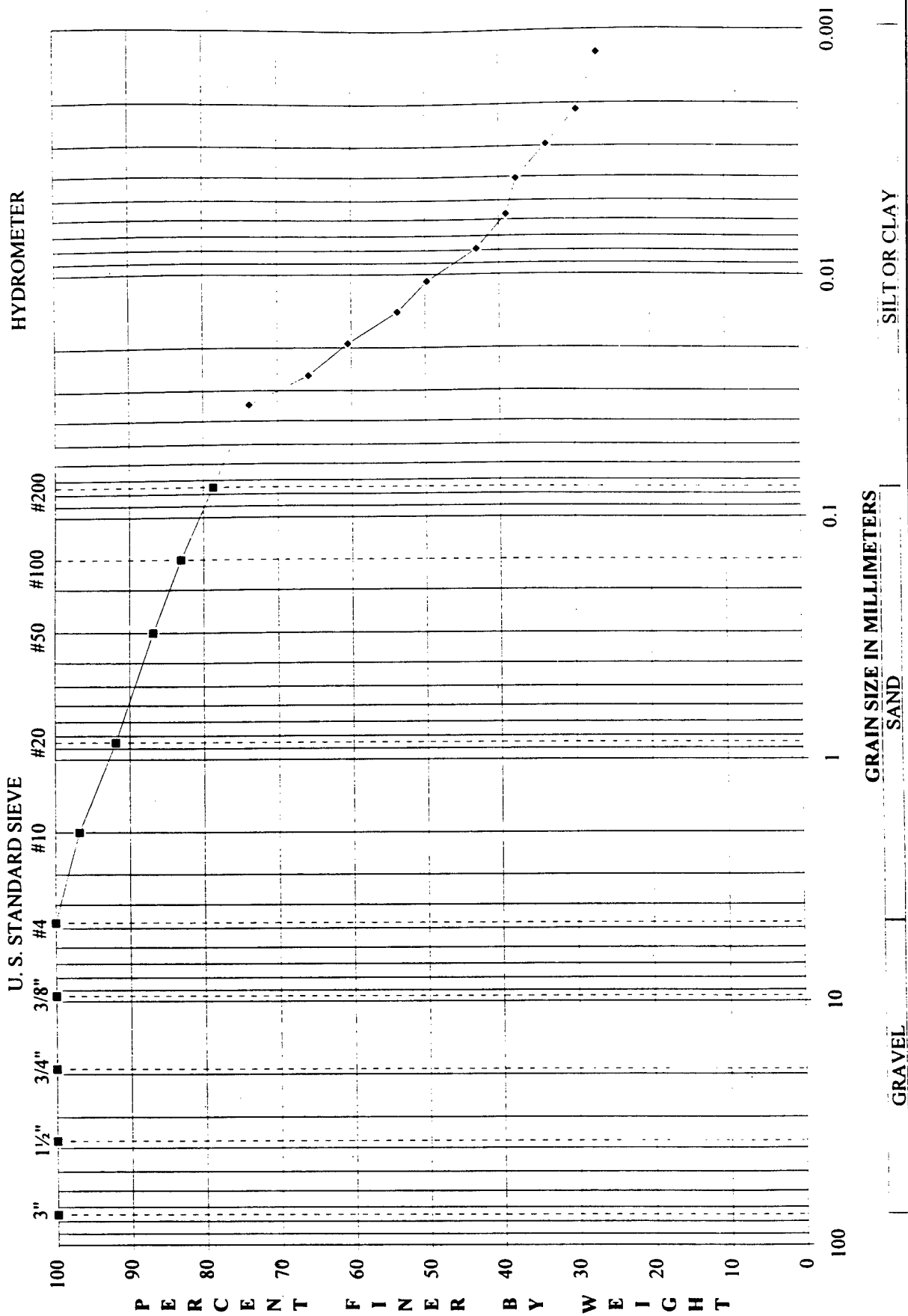
NATURAL MOISTURE CONTENT, % dry basis
20.0

SAMPLE DESCRIPTION
light brown SILT or CLAY with 21% sand
Unified Soil Classification System (USCS) Group Symbol ML, CL, MH, or CH

NOTES

NA=NOT APPLICABLE

PARTICLE-SIZE DISTRIBUTION CURVE
PROJECT SAMPLE B-1 S2, ETL SAMPLE 9601X003-001



ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	USAEC LETTERKENNY	PROJECT SAMPLE I.D.	B-1 S5	PROJECT ANALYST	JRA
JOB NUMBER	9601X003	ETL SAMPLE NUMBER	004	QA/QC ANALYST	RWF
W. O. NUMBER	02281-012-003-0030-00	DATE RECEIVED	01/11/96	DATE COMPLETED	01/18/95

PARTICLE SIZE DISTRIBUTION		
U. S. Standard Sieve Size	Diameter mm	% Finer
3"	75.00	100.0
1½"	37.50	100.0
¾"	19.00	100.0
3/8"	9.500	100.0
#4	4.750	99.2
#10	2.000	90.2
#20	0.850	79.7
#50	0.300	64.6
#100	0.150	59.6
#200	0.075	53.8
HYDROMETER	0.0411	50.9
	0.0301	45.6
	0.0216	42.9
	0.0154	41.6
	0.0113	40.2
	0.0083	34.9
	0.0060	30.9
	0.0042	29.6
	0.0030	28.2
	0.0022	24.2
	0.0013	21.6
	0.0009	21.6

EFFECTIVE SIZES	
% Finer	Diameter mm
60	0.161
30	NA
10	NA
Uniformity Coefficient	Gradation Coefficient
NA	NA

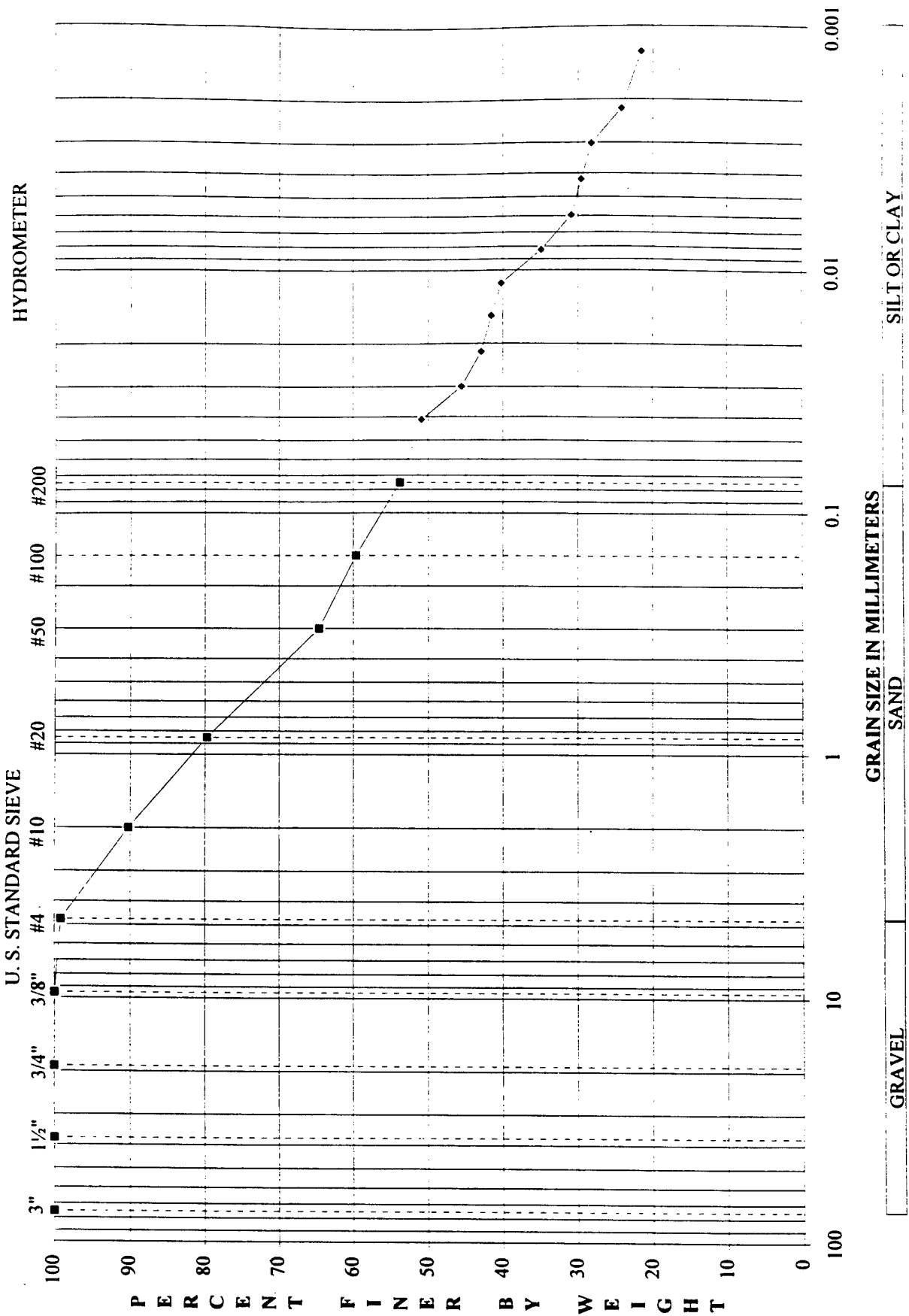
NATURAL MOISTURE CONTENT, % dry basis
25.0

SAMPLE DESCRIPTION
yellow brown SILT or CLAY with 45% sand
Unified Soil Classification System (USCS) Group Symbol ML, CL, MH, or CH

NOTES

NA=NOT APPLICABLE

PARTICLE-SIZE DISTRIBUTION CURVE
PROJECT SAMPLE B-1 S5, ETL SAMPLE 9601X003-004



ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	USAEC LETTERKENNY	PROJECT SAMPLE I.D.	B-2 S2	PROJECT ANALYST	JRA
JOB NUMBER	9601X003	ETL SAMPLE NUMBER	005	QA/QC ANALYST	RWF
W. O. NUMBER	02281-012-003-0030-00	DATE RECEIVED	01/11/96	DATE COMPLETED	01/18/95

PARTICLE SIZE DISTRIBUTION			
U. S. Standard Sieve Size	Diameter mm	% Finer	
3"	75.00	100.0	
1½"	37.50	100.0	
¾"	19.00	100.0	
3/8"	9.500	97.1	
#4	4.750	95.9	
#10	2.000	87.1	
#20	0.850	76.3	
#50	0.300	70.1	
#100	0.150	65.8	
#200	0.075	61.5	
HYDROMETER	0.0414	48.1	
	0.0298	45.5	
	0.0214	42.9	
	0.0153	41.6	
	0.0113	39.0	
	0.0083	33.8	
	0.0060	30.0	
	0.0043	27.4	
	0.0031	24.8	
	0.0022	22.2	
	0.0013	19.6	
	0.0009	19.6	

EFFECTIVE SIZES		
% Finer	Diameter mm	
60	NA	
30	NA	
10	NA	
Uniformity Coefficient	Gradation Coefficient	
NA	NA	

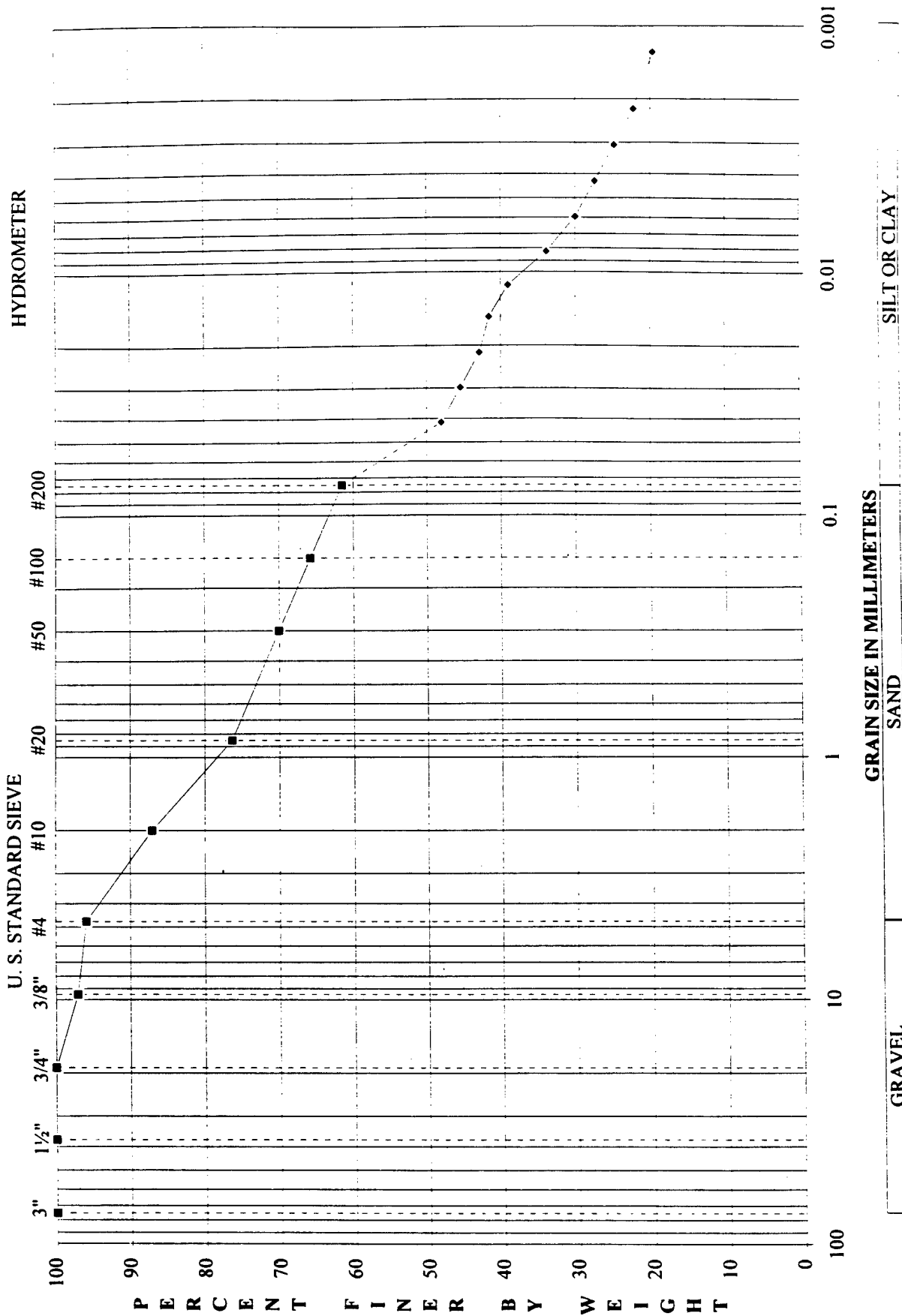
NATURAL MOISTURE CONTENT, % dry basis
14.7

SAMPLE DESCRIPTION
yellow brown SILT or CLAY with 4% gravel and 34% sand
Unified Soil Classification System (USCS) Group Symbol ML, CL, MH, or CH

NOTES

NA=NOT APPLICABLE

PARTICLE-SIZE DISTRIBUTION CURVE
PROJECT SAMPLE B-2 S2, ETL SAMPLE 9601X003-005



ROY F. WESTON, INC. ENVIRONMENTAL TECHNOLOGY LABORATORY

GEOTECHNICAL TESTING DATA AND RESULTS

PROJECT	USAEC LETTERKENNY	PROJECT SAMPLE I.D.	B-2 S5	PROJECT ANALYST	JRA
JOB NUMBER	9601X003	ETL SAMPLE NUMBER	008	QA/QC ANALYST	RWF
W. O. NUMBER	02281-012-003-0030-00	DATE RECEIVED	01/11/96	DATE COMPLETED	01/18/95

PARTICLE SIZE DISTRIBUTION			
U. S. Standard Sieve Size	Diameter mm	% Finer	
3"	75.00	100.0	
1½"	37.50	100.0	
¾"	19.00	100.0	
3/8"	9.500	100.0	
#4	4.750	100.0	
#10	2.000	97.5	
#20	0.850	94.0	
#50	0.300	90.1	
#100	0.150	85.4	
#200	0.075	79.7	
HYDROMETER	0.0343	72.4	
	0.0255	67.2	
	0.0188	61.9	
	0.0139	56.7	
	0.0104	52.8	
	0.0076	47.5	
	0.0056	42.3	
	0.0040	38.3	
	0.0029	34.4	
	0.0021	31.8	
	0.0012	27.8	
	0.0009	26.5	

EFFECTIVE SIZES	
% Finer	Diameter mm
60	NA
30	NA
10	NA
Uniformity Coefficient	Gradation Coefficient
NA	NA

NATURAL MOISTURE CONTENT, % dry basis
19.6

SAMPLE DESCRIPTION
light brown SILT or CLAY with 20% sand
Unified Soil Classification System (USCS) Group Symbol ML, CL, MH, or CH

NOTES

NA=NOT APPLICABLE

